LTIMindtree

LTIMindtree CRYSTAL

Technology Radar 2022-23

“Beyond-The-Horizon” Technologies
for cross-industry enterprises.

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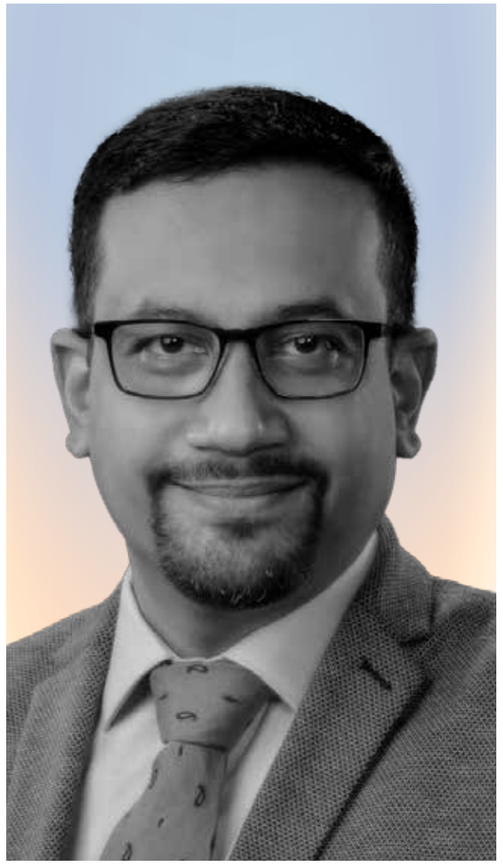
From **CTO's Desk**



Dear All,

In this ever-changing landscape of exponential technologies, LTIMindtree is pioneering solutions in a converging world through initiatives that will form the gateway for radical thoughts.
I am proud to launch our **"LTIMindtree Crystal - Technology Radar"** to help push the frontiers of innovation by bringing **"Beyond-The-Horizon"** technologies to your doorstep.

LTIMindtree Crystal is curated by an inclusive team of technology experts and Crystal scouts ensuring that the trends and emerging technologies that look daunting are demystified. The Crystal is an output of rigorous research by our team of next-gen technology experts and meticulously rated by our Technology Council across parameters that range from the **horizon** to **market potential** and their **adoption phase.** With disruptions and uncertainties ruling our past, present, and future, LTIMindtree Crystal becomes a vital instrument in ensuring that we are well equipped with this precise ability to predict the future technology elements.

As we contemplate challenges faced by clients, we have built a **Horizon-to-Mainstream Incubation** and **Industrialization** funnel to build solutions to solve them. LTIMindtree's Crystal is the first phase of this funnel. This is followed by a deep point-of-view built in collaboration with academics, partners, and industry experts. The Crystal plays a critical role in building our Incubation and Industrialization pipeline.

As we move on this journey of technology empowerment and enable newer ways of thinking and reforming, we would love to know what's on the mind of our Solver's Tribe.

Warm Regards,

Sandeep Deb
Vice President, LTIMindtree

LTIMindtree Crystal – **Introduction**

At LTIMindtree, we have always been at the forefront of an evolving technological landscape and deploying our expertise in nurturing capabilities. With our spirit of **Ubuntu** and our culture of **Shoshin**, we strive to be at the forefront of the new world order. The emergent business world is experiencing an unprecedented degree of interventions and technologies that act as enablers. It's imperative for us to strengthen our technology landscape for developing ingenious solutions and providing business outcomes to our clients. This first edition of "LTIMindtree Crystal - Technology Radar" will act as a catalyst to drive thought leadership and amplify **"Beyond-the-Horizon"** capabilities.

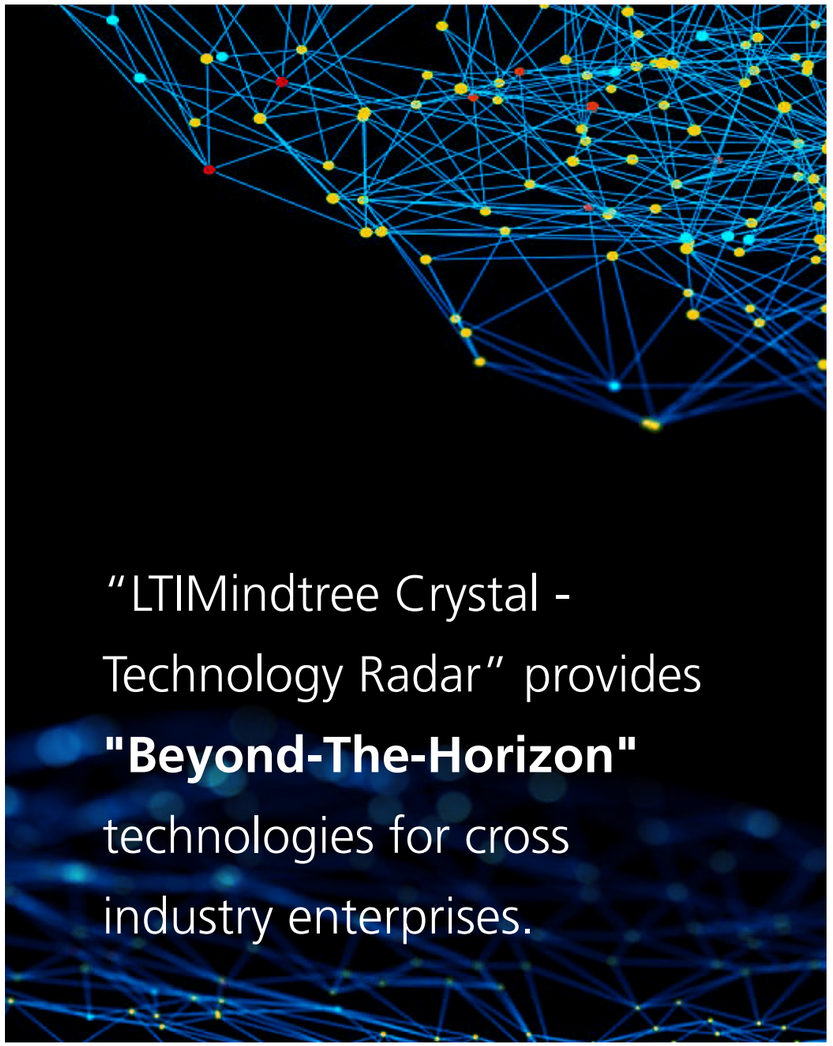
Some of the key envisaged benefits of the Technology Radar are:

Proactive identification and evaluation of trends related to business, technologies, skills, tools, etc.	Future-driven growth strategies with an early-warning system	Opportunity spaces for future research and consideration	Dynamic, intuitive, and comprehensive visualizations for strategic analysis	Strategy and innovation combined centrally to create game-changing growth opportunities

There are overall **56** technology elements across **4** segments and each one of them have been rated on **three parameters** as explained ahead. **Each technology element covers our insights, technology element relationships, key use cases, why this can be a game changer and a featured story.** I request and encourage you to take some time to go through the elements in detail hoping it will inspire, enlighten and take you one step closer to the desired future.

Sachin Jain
Head, LTIMindtree Crystal

LTIMindtree Crystal – **Technology Radar: Ratings**



Horizon

Horizon is defined as the period/ span from the conception of a new idea until it becomes mainstream.

Horizon 1

The technology will reach the mainstream market within 2 years

Horizon 2

The technology will reach the mainstream market within 2 - 5 years

Horizon 3

The technology will take more than 5 years to reach the main-stream market

Market Potential (USD)

The **market potential** of every technology is measured as the expected revenue opportunity of the technology.

0-100Mn	●
100 Million - 500 Millon	●
500 Million - 1 Billion	●
1 Billion - 10 Billion	●
10 Billion +	●

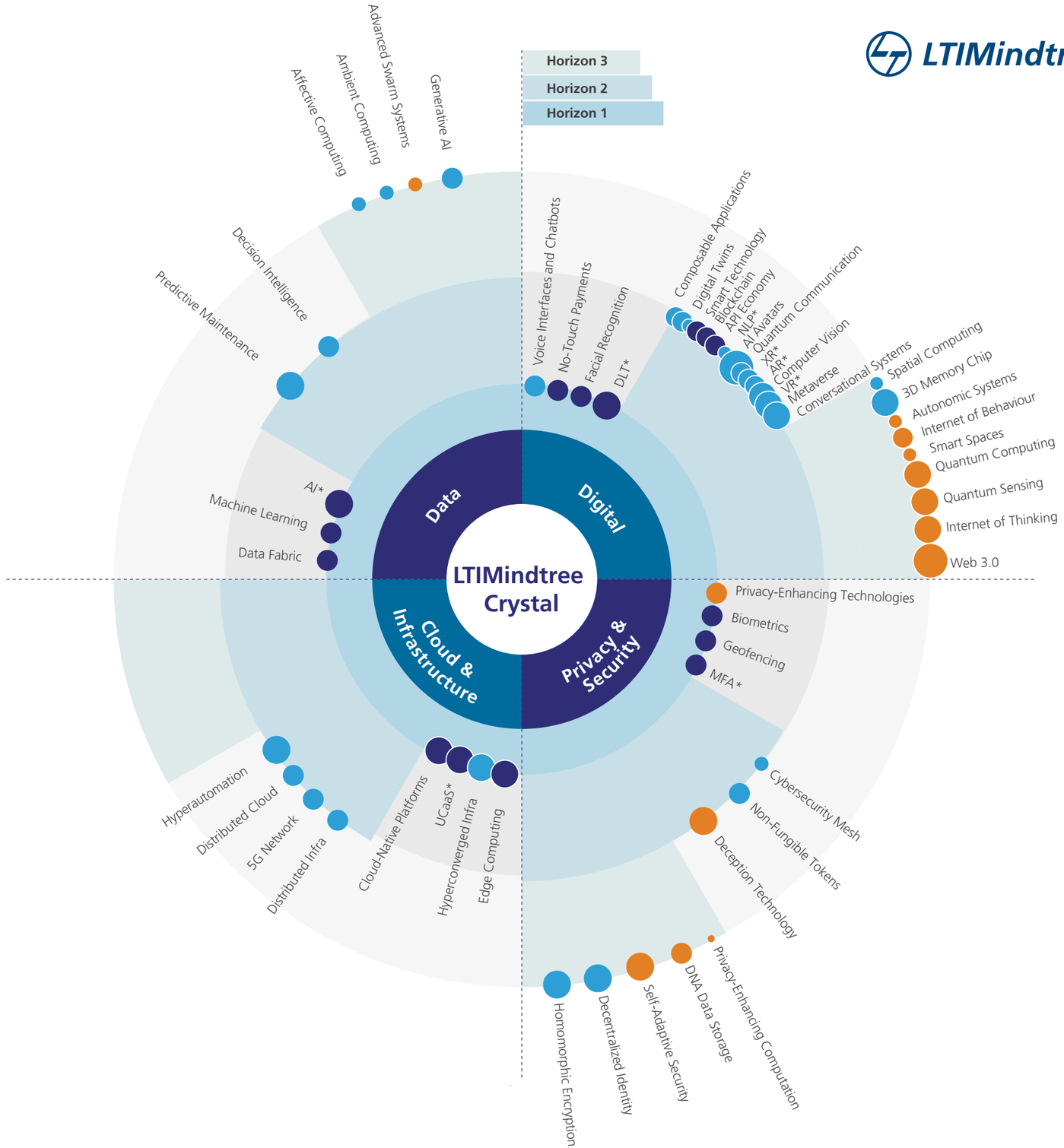
Adoption Phase

Adoption maturity of technology in the market

Emerging	Technology is still in R&D Stage
Improving	Technology has all the hype and promotion of innovation
Mature	Technology is accepted by the masses

LTIMindtree Crystal - **Technology Radar**

Market Potential (USD)	Emerging	Improving	Mature
0-100Mn			
100 Mn - 500 Mn			
500 Mn - 1 Bn			
1 Bn - 10 Bn			
10Bn +			



Abbreviations:

AI – Artificial Intelligence

AR – Augmented Reality

DLT – Distributed Ledger Technology

MFA – Multi-Factor Authentication

NLP – Natural Language Processing

UCaaS – Unified Communications-as-a-Service

VR – Virtual Reality

XR – Extended Reality

LTIMindtree Crystal - **Technology Radar Navigation**

The technologies listed below are arranged according to their corresponding horizon and grouped by their technology segment

Horizon 1

1. **Cloud & Infrastructure**
   - Cloud-Native Platforms
   - Edge Computing
   - Hyperconverged Infrastructure
   - Unified Communications-as-a-Service
2. **Data**
   - Artificial Intelligence
   - Data Fabric
   - Machine Learning
3. **Digital**
   - Distributed Ledger Technology
   - Facial Recognition
   - No-Touch Payments
   - Voice Interfaces and Chatbots
4. **Privacy & Security**
   - Biometrics
   - Geofencing
   - Multi-Factor Authentication
   - Privacy-Enhancing Technologies

Horizon 2

1. **Cloud & Infrastructure**
   - 5G Network
   - Distributed Cloud
   - Distributed Infrastructure
   - Hyperautomation
2. **Data**
   - Decision Intelligence
   - Predictive Maintenance
3. **Digital**
   - AI Avatars
   - API Economy
   - Augmented Reality
   - Blockchain
   - Composable Applications
   - Computer Vision
   - Conversational Systems
   - Digital Twins
   - Extended Reality
   - Metaverse
   - Natural Language Processing
   - Quantum Communication
   - Smart Technology
   - Virtual Reality
4. **Privacy & Security**
   - Cybersecurity Mesh
   - Deception Technology
   - Non-Fungible Tokens

Horizon 3

1. **Data**
   - Advanced Swarm Systems
   - Affective Computing
   - Ambient Computing
   - Generative AI
2. **Digital**
   - 3D Memory Chip
   - Autonomic Systems
   - Internet of Behaviour
   - Internet of Thinking
   - Quantum Computing
   - Quantum Sensing
   - Smart Spaces
   - Spatial Computing
   - Web 3.0
3. **Privacy & Security**
   - Decentralized Identity
   - DNA Data Storage
   - Homomorphic Encryption
   - Privacy-Enhancing Computation
   - Self-Adaptive Security

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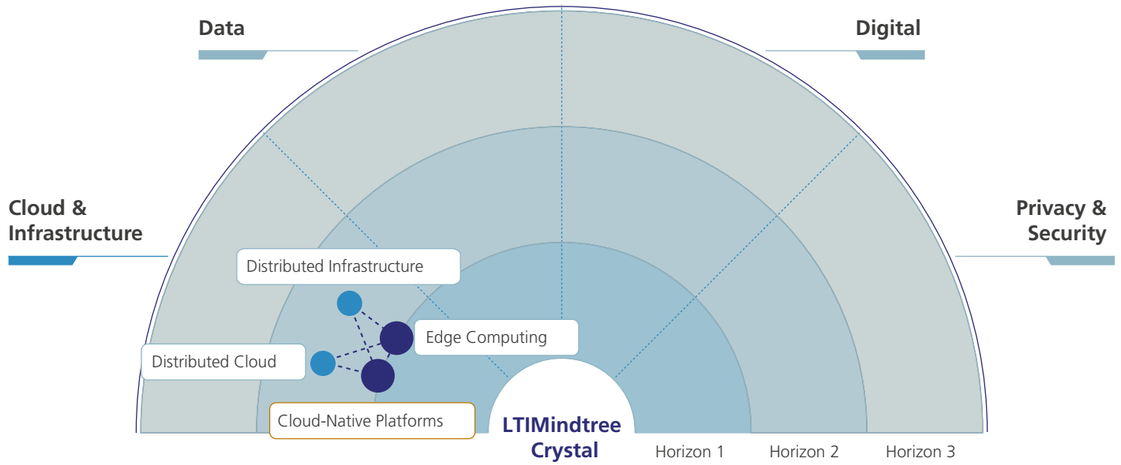
Horizon 1

Cloud-Native Platforms – **Technology Landscape**(1/2)

Technology Rating

Horizon	Market Potential (USD)	Adoption Phase
Horizon 1	0-100Mn	Emerging
Horizon 2	100Mn-500Mn	Improving
Horizon 3	500Mn–1Bn	Mature
	1Bn–10Bn	
	10Bn +	

Radar Positioning & Related Technologies



CRYSTAL **Insights**

Cloud-Native Platforms is a mature technology adopted by businesses for their digital transformation journeys building their **business applications grounds up in the cloud.**

Its growth is driven by the **speed, agility, scalability and resilience** offered by its architecture.

Overview

Cloud-Native Platforms reduce dependencies on infrastructure, freeing up time to focus on application functionality instead. They allow you to build new application architectures that are elastic and scalable — enabling you to respond to rapid digital change and **faster time to market**. They improve on the **traditional lift-and-shift approach to cloud**, which fails to take advantage of the benefits of cloud and adds complexity to maintenance. Cloud-Native Platforms use the core **elasticity and scalability of cloud computing** to deliver faster time to value. They reduce dependencies on infrastructure, freeing up time to focus on application functionality instead.

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Cloud-Native Platforms – **Technology Landscape**(2/2)

How is it a game changer?

Cloud-Native Platforms bring quality, integrity, and consistency to critical areas. Their use also increases **the velocity of software production** and allows delivery teams to put more energy into the creation of innovative product / application features that boost competitive differentiation. All of this supports organizational goals, which may vary in scope between companies, however generally the focus is on meeting customers' evolving needs quickly, securely, and cost-effectively.

Netflix began its cloud journey in 2008, when it experienced major database corruption. Netflix chose the cloud-native approach, rebuilding all its critical business applications using Cloud-Native Technology and has fundamentally changed how the company operates now.

Gartner had predicted Cloud-Native Platforms as the top technology which will enable a smarter and safer digital ecosystem.

Key Use Cases

BFS

Complex, data intensive, and massive transactions execution

Elastic scaling and financial grade reliability of custom build applications

Retail

Seamless applications scaling ensuing right response times during heavy spikes

Media & Entertainment

Improved scalability, performance and availability for digital media platforms

Life Sciences

Virtual healthcare - real-time patient monitoring

Ensure compliance with regulations such as HIPAA and GDPR

Featured Story

Recognized Asian cloud service provider launched Cloud-Native Core Banking solution

An Asian multinational cloud services provider launched its Cloud-Native Core Banking solution, a foundation for agile innovation of traditional banks and new digital banks. The solution aims to provide a stable cloud-native platform for offloading mainframes, building new core systems for traditional banks, and powering digital banks. To achieve this, the cloud provider partnered with a banking software solution provider to launch a joint cloud-native digital loan solution. Built on cloud, the solution adopts enterprise-level microservices banking framework EDSP released by the banking technology leader, creating a novel experience, capabilities, speed, architecture, and a strong foundation of future.

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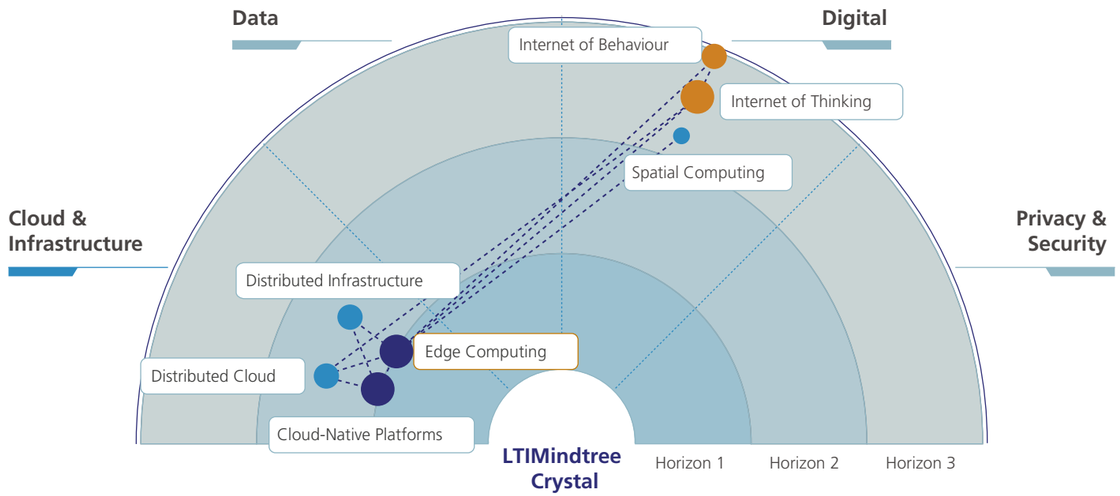
Edge Computing – **Technology Landscape**(1/2)

Technology Rating

Horizon	Market Potential (USD)	Adoption Phase
Horizon 1	0-100Mn	Emerging
Horizon 2	100Mn-500Mn	Improving
Horizon 3	500Mn–1Bn	Mature
	1Bn–10Bn	
	10Bn +	

Radar Positioning & Related Technologies



CRYSTAL Insights

IDC estimated that there will be **55.7 billion connected IoT devices by 2025**, generating almost 80B zettabytes of data which is driving the growing adoption of edge computing technology.

It is a **mature technology** and would experience further growth as businesses aim to offer real-time, seamless experience to its customers.

Overview

Edge Computing is a computing framework in which data processing occurs closer to the data source–such as **IoT devices**–instead of in **central cloud servers**. The shift improves bandwidth availability and reduces latency, speeding up analysis and response times. Edge Computing is used in **smart homes, autonomous vehicles, and communication applications** (including gaming) that require low latency.

Edge Computing – **Technology Landscape**(2/2)

How is it a game changer?

Edge Computing can make real-time decision-making a reality by handling the scale and complexity of the vast quantities of data generated by connected sensors and devices. In areas such as **autonomous driving** and the operation of digital twins, where there is the need for low latency. Edge Computing, aided by 5G communications, will play an essential role.

Technology advancements in various fields has led the adoption of edge computing beyond the boundaries of IoT. It has also unlocked opportunities to use edge computing for several other use cases. Technology giants like Google, Amazon, NVIDIA and Intel have launched highly capable and efficient hardware SoCs in tiny form that could easily fit into sensors, wearables, smartphones, bulbs and microwave ovens. Online gaming fueled the need for real-time data processing and analysis with guaranteed sub-microseconds latency for global users. All these developments, research and innovations in the Edge Computing space have opened business opportunities for the global enterprises.

Key Use Cases

Manufacturing

- Predictive maintenance
- Precision monitoring and control of the machines

Life Sciences

- Connected ambulance
- In-hospital patient monitoring
- Remote patient monitoring and care

BFS

- Personalization of customer engagement
- Advanced data analytics for real-time cyber-security

Retail

- Just Walk Out (JWO) experiences
- Analysis of customer behavior in near real-time for an improved shopping experience

Featured Story

British Formula 1 Racing Team relies on edge computing at the racetrack's edge

British Motor Company with it's technology center based in Surrey, England securely delivers apps and data to track crews and guests using the Edge Computing technology. For them, the Edge Computing based solution is wherever in the world the company's Formula 1 racing team is competing around the year. An IT setup at each racing site links the entire team, including mechanics, engineers, crew members, guests and the drivers of 2 Formula 1 race cars. Using this technology they try to find ways of going faster and getting marginal gains as an outcome. They have recently showcased an example of a technician who's a tire expert, accessing real-time information from the field. "He'll be analyzing all of the data coming from the car to predict what tire we should move to next," which is very critical in this modern era of Formula 1 racing.

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Hyperconverged Infrastructure (HCI) – **Technology Landscape(1/2)**

Technology Rating

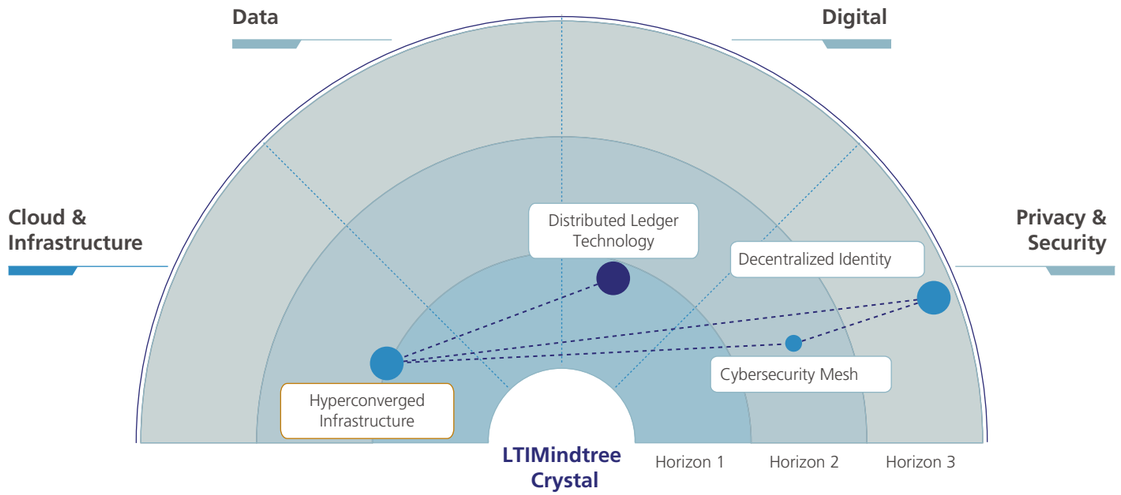
Horizon	Market Potential (USD)	Adoption Phase
Horizon 1	0-100Mn	Emerging
Horizon 2	100Mn-500Mn	Improving
Horizon 3	500Mn–1Bn	Mature
	1Bn–10Bn	
	10Bn +	

CRYSTAL **Insights**

HCI adoption continues to grow in data centers as organizations are using it to align their current and future business strategies.

According to S&P Global, organizations are increasingly adopting HCI for Kubernetes- orchestrated workloads. **Organizations running Kubernetes on HCI jumped from 29% in 2020 to 45% in 2021.**

Radar Positioning & Related Technologies



Overview

Hyperconverged Infrastructure (HCI) refers to an IT framework that combines the various layers of infrastructure—**storage, computing, networking, and management**—into a **single, unified data center solution**. It enables a software-defined IT infrastructure to run on standard, off-the-shelf servers by virtualizing all the hardware elements of a **conventional data center environment**. The technology aims to reduce infrastructure complexity, thereby increasing scalability and agility. Adoption of this technology is driven by the growing movement towards the cloud.

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Hyperconverged Infrastructure (HCI) – **Technology Landscape**(2/2)

How is it a game changer?

AI-enabled HCI will impact supply chains and logistics for disaster recovery and virtually support **real-time, analytics-driven decision-making**. Organizations can dynamically deploy transport mechanisms as required.

In the healthcare industry, any healthcare legislation that requires a retooling of enterprise systems to accommodate new data storage, security, and process standards can be seamlessly reconfigured by HCI.

The popularity of **Infrastructure-as-a-Service (IaaS)** solutions will enable the growth of HCI, primarily due to the reduced cost of ownership and emphasis on **virtual desktop and server virtualization**.

AI-enabled Hyperconverged Infrastructure is disrupting legacy data center infrastructure, enabling pattern analysis to make companies more **responsive, flexible, and agile**.

The technology is projected to impact across industries including IT, retail, finance, healthcare, and manufacturing.

Key Use Cases

Life Sciences

Low latency health monitoring equipment

Media & Entertainment

High density media streaming

Content disaster recovery

BFS

Real time digital transaction & data analytics

Technology

Virtual desktop infrastructure

Data 'In-Transit' analytics

Featured Story

Japanese city selects a hybrid multicloud computing leader to create the first hybrid cloud environment

A Japanese City government has deployed a hybrid multicloud computing leaders' Hyperconverged Infrastructure solution to create the first hybrid cloud environment used by a local government in Japan. The city is the largest ordinance-designated city with approximately 1.96 million people. It combines the functions of an urban city including buildings and residences with those of a natural city in the suburbs. This has reduced the city's IT complexity and operational burdens because it enables applications to be managed on-premise and in the cloud, on a cloud giants bare metal infrastructure, using a single interface.

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Unified Communications-as-a-Service (UCaaS) - **Technology Landscape(1/2)**

Technology Rating

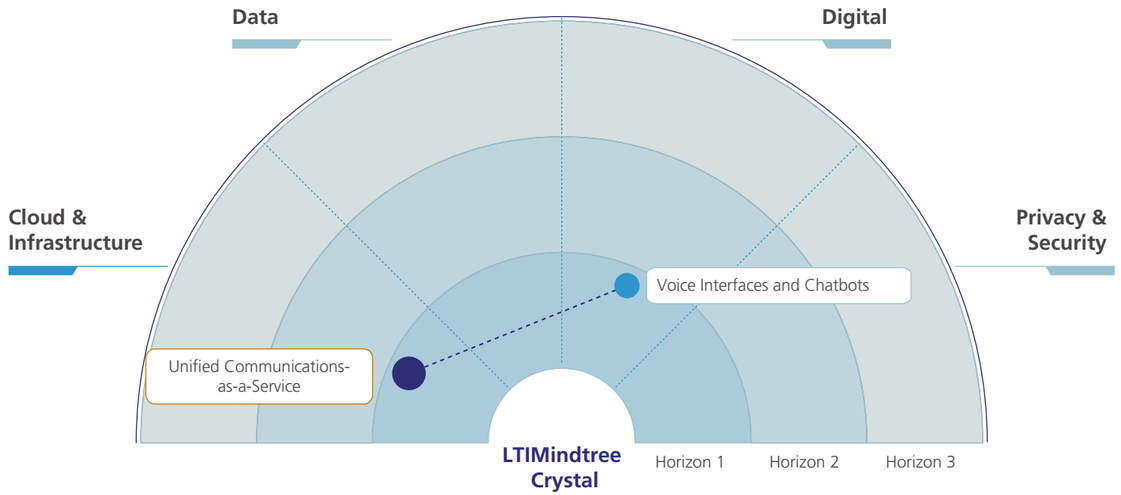
Horizon	Market Potential (USD)	Adoption Phase
Horizon 1	0-100Mn	Emerging
Horizon 2	100Mn-500Mn	Improving
Horizon 3	500Mn–1Bn	Mature
	1Bn–10Bn	
	10Bn +	

CRYSTAL Insights

UCaaS is a **mature technology** and used for workforce collaboration from small organizations to large-scale enterprises.

Remote and hybrid work cultures will further drive the adoption of this technology for better workforce collaboration in the near future.

Radar Positioning & Related Technologies



Overview

Unified Communications-as-a-Service (UCaaS) refers to a cloud-delivered unified communications model that supports various communications functions, including enterprise telephony, meetings (audio/video/web conferencing), unified messaging, instant messaging, & presence (personal and team), & mobility & communications- enabled business processes. Unified Communications focuses on eliminating the common problems that companies face when it comes to keeping people connected. Rather than merely offering VoIP or video messaging, the technology combines everything companies need to reach their employees and customers, in the same environment.

Unified Communications-as-a-Service (UCaaS) - **Technology Landscape**(2/2)

How is it a game changer?

IDC estimated that worldwide UCaaS service provider revenue, including OTT providers, will reach **USD 16.1 billion** in 2024 with a **CAGR of 7.0%** over the 2019-2024 forecast period.

The subscription model offered by UCaaS has had a positive impact on its increasing adoption globally. Businesses are increasingly looking at UCaaS as a cost-effective means of providing communications solutions that support enhanced productivity and collaboration. Through the cloud, UCaaS simplifies the deployment and management of communication strategies. Thus, UCaaS positions itself as a strategic and competitive collaboration/ communication technology, with many opportunities for growth and innovation.

Key Use Cases

BFS

- Mobile enablement for off-premise banking at different locations
- Seamless personal banking experience to customers

Retail

Personalized customer experience:

- Contact center efficiency
- Single source for communications

Life Sciences

- Enabling Telehealth
- Improving critical, patient - doctor knowledge flow
- Connecting hospital staff and paramedics

Manufacturing

- Communicate seamlessly from the warehouses to regional offices
- Improve employee mobility

Featured Story

A Swedish multinational networking and telecommunications company acquires an American cloud communications provider

A Swedish multinational networking and telecom provider completed its acquisition of a US based cloud communications provider supporting former's strategy to leverage technology leadership to grow its mobile network business and expand into enterprise. The acquisition provides the telecom giant with access to powerful building blocks to offer a full suite of communications solutions including, CPaaS, UCaaS and CCaaS.

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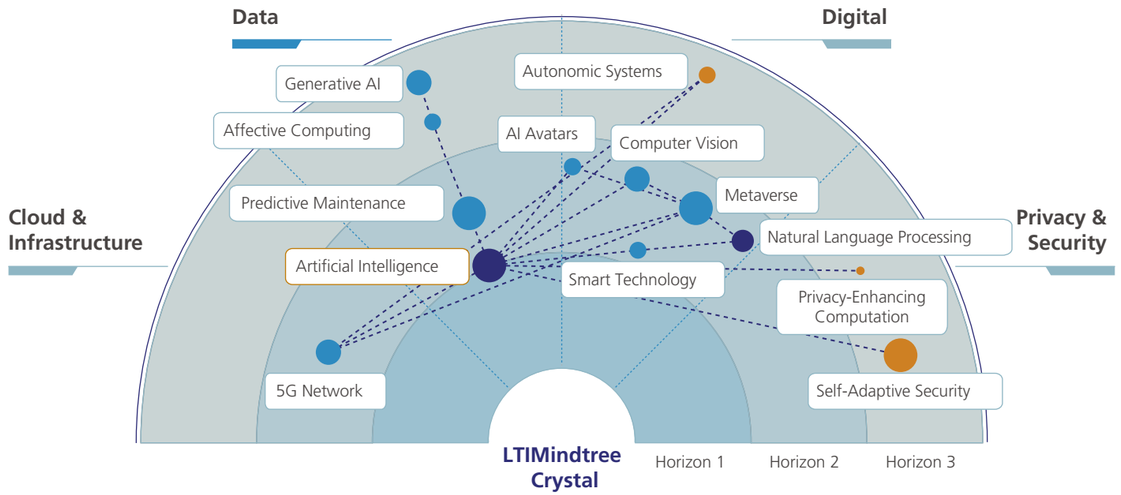
Artificial Intelligence - **Technology Landscape**(1/2)

Technology Rating

Horizon	Market Potential (USD)	Adoption Phase
Horizon 1	0-100Mn	Emerging
Horizon 2	100Mn-500Mn	Improving
Horizon 3	500Mn–1Bn	Mature
	1Bn–10Bn	
	10Bn +	

Radar Positioning & Related Technologies



CRYSTAL **Insights**

Enterprises are gaining meaningful value in terms of revenue and process optimization through investments in AI.

While general-purpose AI is mature, the industry is working on **specialized use cases** for domain-centric solutions.

Overview

AI is a wide-ranging branch of computer science concerned with building **smart machines** capable of performing tasks that typically require **human intelligence**. Artificial Intelligence is the **simulation of human intelligence** processes by machines, especially computer systems. AI leverages computers and machines to mimic the **problem-solving and decision-making** capabilities of the human mind. AI works by combining **large amounts of data with fast, iterative processing and intelligent algorithms**, allowing the software to learn automatically from patterns or features in the data.

Artificial Intelligence - **Technology Landscape**(2/2)

How is it a game changer?

AI is the most popular and **dynamic innovation of the 21st century**, has begun to rule the global stage with its intelligent functions. Organizations are gaining a competitive edge thanks to this **cutting-edge** technology in fiercely competitive sectors.

Automotive businesses are being driven by **AI** models to **create autonomous vehicles** that incorporate Augmented Reality and Virtual Reality to improve the **in-vehicle experience** and get people where they need to go.

AI is a huge help in the **healthcare industry, especially in the wake of the COVID-19 pandemic, with virtual assistants, robotic surgeons, early disease detection, reminding patients to take their medications** on time, and many other applications.

AI models give **farmers** the knowledge to **analyze weather predictions, flaws, and deficits in soils and crops**, as well as robots, to assist them with harvesting.

Key Use Cases

Life Sciences

- Analyze unstructured clinical notes on patients using NLP
- AI-based healthcare analytics for diagnosis and treatment

Manufacturing

- Capture and process big data from sensors on the shop floor
- Self-optimized machines to automate production processes

BFS

- Detect anti-money laundering pattern
- Credit scoring by analyzing data from traditional and non-traditional data sources

CPG & Retail

- Chatbots to assist with customer service
- In-store Customer assistance
- Customer satisfaction tracking
- Cashier free stores

Featured Story

Canada based furniture store vendor achieves a 239% increase in automated customer support workflows using an AI startup's conversational AI engagement platform

A Conversational AI Engagement Platform, through integration with a provider of retail software solutions to home furnishings and appliance retailers, has enabled a leading furniture provider in Canada to turn their post-purchase operation into a full brand experience, re-defining loyalty and driving more sales. With Conversational AI Engagement Platform, the furniture vendor was able to consolidate these separate solutions into a single platform for all customer engagement and fulfillment operations.

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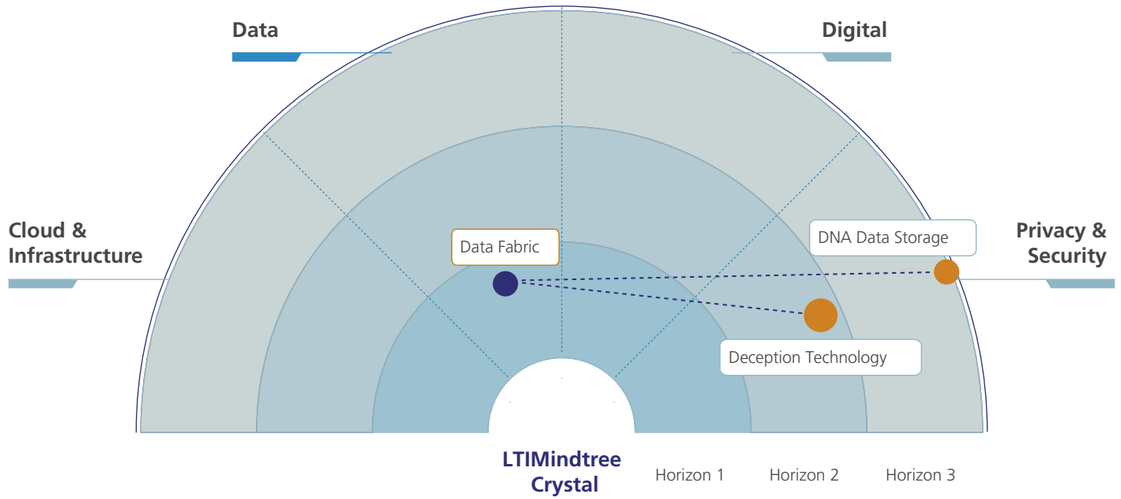
Data Fabric – **Technology Landscape**(1/2)

Technology Rating

Horizon	Market Potential (USD)	Adoption Phase
Horizon 1	0-100Mn	Emerging
Horizon 2	100Mn-500Mn	Improving
Horizon 3	500Mn–1Bn	Mature
	1Bn–10Bn	
	10Bn +	

Radar Positioning & Related Technologies



CRYSTAL **Insights**

With the increasing use of digital apps, the data fabric technology is expected to witness promising growth.

Gartner notes that it reduces time for integration design by **30%**, deployment by **30%** and maintenance by **70%** because the technology designs draw on the ability to use/reuse and combine different data integration styles.

Overview

Data Fabric is an architectural approach and a set of technologies that allow you to break down data silos and simplify data access within an organization. It enables accessing, ingesting, integrating, and sharing data across the enterprise in a governed manner, regardless of location, whether it is in your on-premise systems or in multiple public cloud environments. Thus, with a data fabric, enterprises elevate the value of their data by providing the right data, at the right time, regardless of where it resides.

Data Fabric – **Technology Landscape**(2/2)

How is it a game changer?

Data Fabric enables **enterprises** to **execute and process data locally**, eliminating the need to consolidate all disparate and diverse data into a **single data lake in a central location** and then run algorithms on it to **gain insights**.

Traditional systems are rendered obsolete in such modern scenarios because they necessitate the **costly operation** of moving large amounts of data and keeping it up to date in all copies.

Data Fabric enables easy **distributed data** processing and computation. In addition, it allows organizations to keep data where it is across departments while connecting all sources in a flexible manner.

Data Fabric also ensures **workflow composability and data democratization**. All these benefits of data fabric widening its applications in **healthcare, fintech, product engineering, marketing, retail, and other** sectors to reap the advantages of an **agile and transformative IT ecosystem**.

Moreover, Data Fabric speed up value from AI and ML usage, bringing ROI faster.

Key Use Cases

Life Sciences

- Data sharing across hospitals
- Optimize the supply chain to improve patient care and hospital efficiency

BFS

- Ingest and store data consumed through open banking APIs
- Provisioning enterprise data and insights for third parties

CPG & Retail

- Real-time inventory insights
- Provide a single platform environment for collecting, curating, and analyzing

Technology

- AI data collaboration
- End-to-end security coupled with assisted data integration and self-serve analytics

Featured Story

A US based technology company and a data management startup extend strategic partnership to accelerate and improve enterprise data intelligence and privacy

The data management startup's integration with the US tech giant's data fabric platform enables their joint customers to benefit from a holistic solution that addresses enterprise and public sector organizations' most difficult and urgent data privacy, security, and governance challenges. Customers can now leverage the combined solution, making it easier than ever to unlock valuable insights from sensitive data, while also complying with privacy, security and governance regulations.

Machine Learning (ML) – **Technology Landscape(1/2)**

Technology Rating

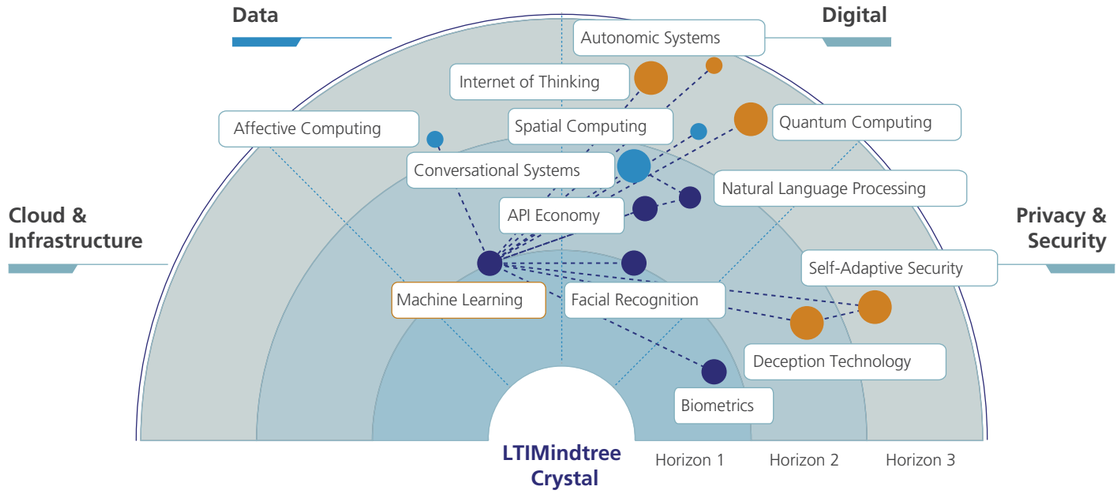
Horizon	Market Potential (USD)	Adoption Phase
Horizon 1	0-100Mn	Emerging
Horizon 2	100Mn-500Mn	Improving
Horizon 3	500Mn–1Bn	Mature
	1Bn–10Bn	
	10Bn +	

CRYSTAL **Insights**

Machine Learning is already adopted by several companies due to its potential to provide **more accurate predictions** and business decisions.

Development of self-learning technology will fully automate ML capabilities to take decisions without human intervention and will further expand its applications.

Radar Positioning & Related Technologies



Overview

Machine Learning is a sector of **AI centered around imitating human intelligence** by enabling systems to learn and continuously improve themselves using data rather than explicit instructions. Machine Learning algorithms are capable of tackling problems beyond the computational capacity of traditional algorithms by extrapolating conclusions from data and forming their own sets of rules. Machine Learning can handle **large volumes of unstructured data and generate insights** that can solve complex predictive problems.

Machine Learning (ML) – **Technology Landscape**(2/2)

How is it a game changer?

Machine Learning can be used to analyze data to detect and predict health issues as well as effective treatments.

ML can enable hyper-personalization to improve customer satisfaction by making highly relevant recommendations.

ML can power **self-driving vehicles, predictive maintenance, and quality control. In the financial sector**, it can be used for risk assessment and to predict market fluctuations.

It improves cybersecurity and logistics management and support **counterterrorism and crime-fighting efforts.**

Machine Learning can be used to analyze any form of unstructured data so that systems can make predictions and exhibit human-like **decision-making.**

Some of the potential applications of this technology include more accurate web search results, highly personalized products, and service offerings, and automated self-learning systems.

Key Use Cases

Media & Entertainment

- Tailor made recommendation engine
- Personalized marketing

Life Sciences

- Computer-assisted diagnosis
- Patient mortality risk prediction

BFS

- Fraud detection for secure transactions
- Algorithmic trading

Technology

- Automated data ingestion and processing
- Data assisted complex decisions

Featured Story

US based fintech startup and an end-to-end lending solutions provider partner to integrate powerful AI within loan origination system

A US-based fintech startup announced its partnership with a lending technology solutions and services provider for credit unions. Credit underwriting with **machine learning algorithms** allows a credit union to use **thousands of data points to determine a credit score**, meaning the lender can make more **equitable credit decisions** than when using traditional methods and other competing models.

Distributed Ledger Technology – **Technology Landscape(1/2)**

Technology Rating

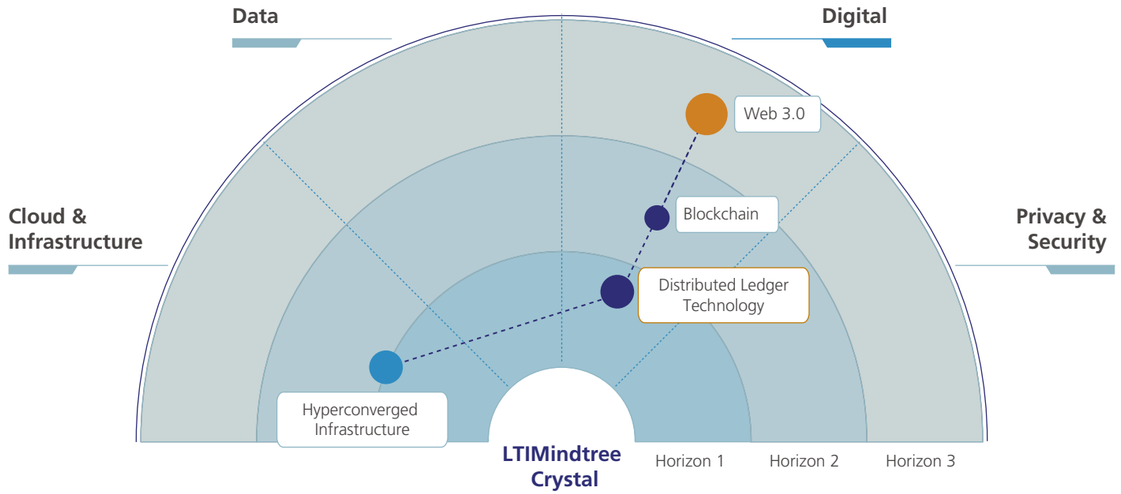
Horizon	Market Potential (USD)	Adoption Phase
Horizon 1	0-100Mn	Emerging
Horizon 2	100Mn-500Mn	Improving
Horizon 3	500Mn–1Bn	Mature
	1Bn–10Bn	
	10Bn +	

CRYSTAL **Insights**

Transparency, trust, security, and identity management are the building blocks of DLT and are driving the adoption of this technology.

Blockchain is the de-facto implementation for DLT. However, it is being challenged by products like **Hashgraph and IOTA Tangle,** innovating newer DLT applications for businesses.

Radar Positioning & Related Technologies



Overview

Distributed Ledger Technology (DLT) refers to the storage of data in multiple ledgers using a distributed network of **computer servers (nodes)**, with each ledger bearing the same records. DLT provides the **technological infrastructure and cryptographic protocols** required to facilitate the simultaneous access, validation, and updating of records, creating a secure, decentralized, and immutable digital database. DLT is being used extensively in the finance industry and has seen its applications extend to **supply chain management, education, farming, mining, entertainment, and even government operations**.

Distributed Ledger Technology – **Technology Landscape**(2/2)

How is it a game changer?

DLT has great potential to revolutionize the way governments, institutions, and corporation's work. It can help governments with **tax collection, the issuance of passports, recording land registries and licenses, and the outlay of Social Security benefits as well as**
voting procedures.

Technology is making waves in industries such as **finance, music and entertainment, diamond and other precious assets, art, supply chains** of various commodities, and more. Technology giants including IBM and Microsoft are experimenting and exploring use cases within blockchain technology.

Some of the most popular distributed ledger protocols are Ethereum, Hyperledger Fabric, R3 Corda, and Quorum.

Key Use Cases

BFS

Know Your Customer (KYC) and fraud prevention

Faster cross-border payments

Supply Chain & Logistics

Smart contracts

Transparency is enabled by visibility and traceability

Life Sciences

Enable secure access to Personal Health Records (PHRs) using smart contracts

Manufacturing

Quality tracking of products and processes

Auditing via DLT ensures neutral assessment of the auditors

Featured Story

Two American investment banking services companies Test Drive DLT

Two of the leading US based investment banking and financial services companies have completed the industry's first agency securities lending transactions via a DLT platform of a financial technology vendor focused on securities finance and repo transactions.

US based multinational retail corporation in Canada uses blockchain to solve supply chain challenges

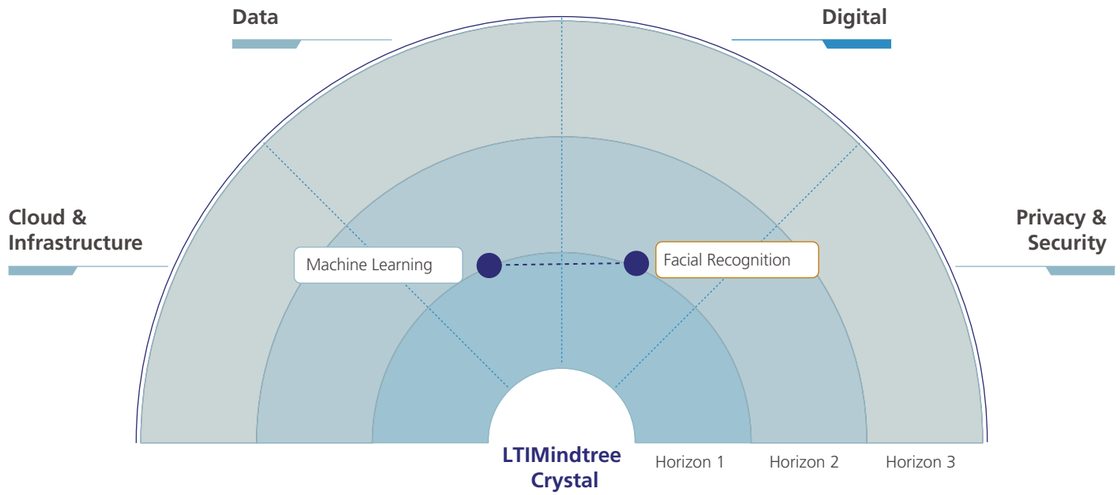
A US based multinational retail corporation in Canada applied blockchain to solve a common logistics nightmare: payment disputes with its 70 third-party freight carriers. To solve the problem, it built a blockchain network. The system has not only virtually eliminated the payments problem; it also has led to significant operational efficiencies.

Facial Recognition – **Technology Landscape**(1/2)

Technology Rating

Horizon	Market Potential (USD)	Adoption Phase
Horizon 1	0-100Mn	Emerging
Horizon 2	100Mn-500Mn	Improving
Horizon 3	500Mn–1Bn	Mature
	1Bn–10Bn	
	10Bn +	

Radar Positioning & Related Technologies



CRYSTAL Insights

Adoption of Facial Recognition technologies is soaring and will continue to rise as **businesses upgrade their physical security and access control solutions** in the years ahead.

However, individuals and governments still grapple with the **ethical implementation** of facial recognition.

Overview

A **facial recognition system** is a technology capable of matching a **human face** from a **digital image or a video frame** against a database of faces, typically employed to authenticate users through ID verification services, and works by pinpointing and measuring facial features from a given image. Facial recognition uses biological markers such as **facial features, voice, fingerprint, and iris recognition to identify users and authenticate identity**.

Facial Recognition – **Technology Landscape**(2/2)

How is it a game changer?

In addition to using facial recognition for security purposes, the technology will increasingly see adoption in adjacent industries including **banking, healthcare, and retail**. However, security functions will also continue to increase. Facial identification has the potential to replace government-issued identification cards completely, and countries could embrace biometric technology on a national level. Smart cities will rely heavily on this technology, and fields like continuous user verification are employing innovative methods to provide increased security.

COVID-19 has accelerated these technologies' progress, and new developments include enabling facial recognition while people wear masks. Facial recognition is enabled by combining next-generation mobile, 5G, and edge technologies. AI and IoT have also been deployed to improve functionality, specifically within digital security. Current challenges center around safety and privacy issues as ways to circumvent authentication remain.

Key Use Cases

BFS

eKYC to authenticate customers and improve fraud detection

Automotive

Lock, unlock, start vehicle using biometrics

Adjust seating, head-up display, side mirror

Capture eye tracking to prevent accidents

Retail

Facial recognition in stores to combat shoplifting and fraud

Government

Surveillance and security in high security zones

Featured Story

Largest Australian bank works with a tech giant on facial recognition for ATMs

One of the four largest financial institutions in Australia and a technology giant have partnered for a proof-of-concept ATM that identifies customers using facial recognition. The cloud-based proof-of-concept is powered by AI, and it was developed using the technology giant's cognitive services. The project aims to take a step towards a cardless future. By removing the need for physical cards, it can also minimise the risk of card fraud and skimming.

Back to Navigation

No-Touch Payments – **Technology Landscape(1/2)**

Technology Rating

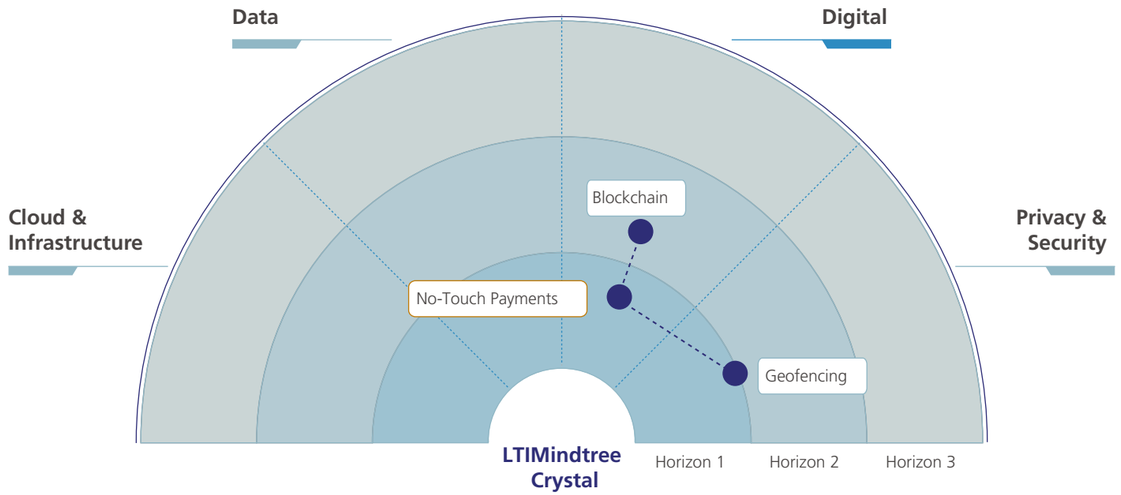
Horizon	Market Potential (USD)	Adoption Phase
Horizon 1	0-100Mn	Emerging
Horizon 2	100Mn-500Mn	Improving
Horizon 3	500Mn–1Bn	Mature
	1Bn–10Bn	
	10Bn +	

CRYSTAL **Insights**

In 2020, the COVID-19 **pandemic and ensuing demand for more hygienic, touch-free payment alternatives** led to a significant increase in contactless payment adoption.

While mobile payments and contactless cards have accounted for a minority of payments in the past, the pandemic has clearly driven change in consumer behavior and retailers to accelerate their adoption of the technology.

Radar Positioning & Related Technologies



Overview

No-Touch Payments refer to payments made by transferring money electronically through debit/credit cards and are expanding to include **virtual payment methods such as online and mobile transfers. AI, machine learning, and blockchain** are advancing the field of No-Touch Payments by enabling more secure and faster transactions. Digital solutions like No-touch Payments are rapidly gaining adoption, particularly in the wake of **COVID-19**. However, the risk of fraudulent activity and cybercrime, especially when dealing with high-value transactions remains.

No-Touch Payments – **Technology Landscape**(2/2)

How is it a game changer?

Digitalization have been disrupting financial services by offering evolving payment channels. Rapid digitalization will be a standard to meet the demands of today's highly mobile consumers.

Geofencing technology will make No-Touch Payments seamless, when a consumer enters a specific store using auto-payment, eliminating the need for checkout.

In the future, AI may enable a neural network capable of intuitively detecting when and where a consumer wants to spend money.

Likewise, the IoT will make it possible for smart home appliances and wearables to make payments, creating a truly contactless world.

As the cashless economy emerges, No-Touch Payments will become the standard and be implemented across all industries, with **retail and banking leading the charge**.

The IoT will make it possible for smart devices and wearables to make payments and complete purchases.

Key Use Cases

Media & Entertainment

Micro-transactions

Subscriptions purchase and renewals

Retail

Payments & Check-outs via facial recognitions

BFS

Contactless card payments for transaction, with a point of sale (POS) terminal via NFC or RFID

Healthcare

Tap-to-pay or e-wallets for touch-free payments for convenience and hygiene in hospitals

Featured Story

Dutch rail network to trial contactless open loop fare payments

A rail operator in the Netherlands is to pilot a contactless open loop fare payment system that will enable passengers to pay for their train fares by tapping their physical debit or credit card or their digital debit card stored on a smartphone or smartwatch at the beginning and the end of their journey.

Back to Navigation

Voice Interfaces and Chatbots – **Technology Landscape(1/2)**

Technology Rating

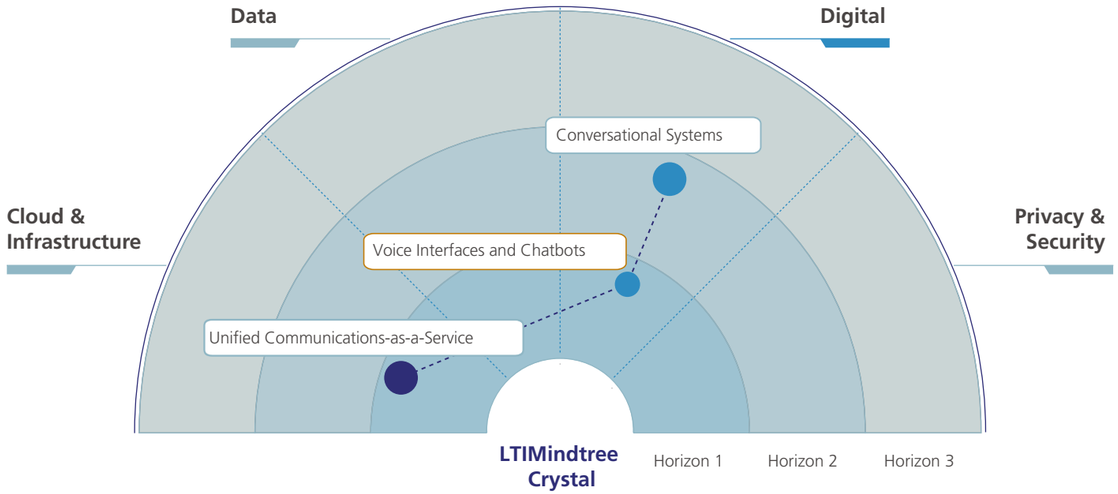
Horizon	Market Potential (USD)	Adoption Phase
Horizon 1	0-100Mn	Emerging
Horizon 2	100Mn-500Mn	Improving
Horizon 3	500Mn–1Bn	Mature
	1Bn–10Bn	
	10Bn +	

CRYSTAL **Insights**

Adoption of voice interfaces and chatbots is improving as wide array of consumer and industrial devices are now being integrated with voice assistants.

Voice chatbots are the future of interaction and will be the preferred mode of input in the next couple of years. However, enterprise developers must **focus on integrating voice assistance into special workflows to improve the quality and precision** of in-app voice recognition and language understanding.

Radar Positioning & Related Technologies



Overview

Voice interfaces and chatbots are computer programs that allow **humans to converse and interact with computers** through either **spoken commands or written text**. Chatbots and voice assistants, in **combination with AI technologies**, can fundamentally change the way companies work. Chatbots map the communication via messenger, while voice assistants map the communication via voice. These systems can be used in your own apps, websites, messengers, social media or even in your own hardware.

Voice Interfaces and Chatbots – **Technology Landscape**(2/2)

How is it a game changer?

A common trend in chatbots and voice assistants is to go where the users are to be available on the interfaces with which the customers want to interact. With AI-powered and data-backed abilities, chatbots can personalize omnichannel customer engagement, support key business functions, and unearth intelligent insights. Aided by the wave of IoT and digitalization, AI-powered chatbots can truly be a game-changer.

Chatbots will see further **advancements in flexible connectors and better integration with API and third-party/backend software like RPA, ERPs, and CRM**. Businesses will deploy hybrid chatbot models that leverage both linguistic and machine learning capabilities. This will provide greater flexibility and speed to scale AI-oriented transformation and drive business bottom-line and ROI.

According to McKinsey, human customer support interactions will be reduced by **30%** by 2022. This essentially means that chatbots and voice bots have the potential to own up to **70%** of these interactions in the future.

Key Use Cases

BFS

- Loan service
- Consumer banking and finance
- Personal financial information

Travel & Hospitality

- Reservations, ordering and delivery
- Refund or reschedule assistance

Media & Entertainment

- Subscription management
- On-demand content

Life Sciences

- Screen symptoms and diagnose diseases
- Streamline scheduling appointments
- Conversational self-service

Featured Story

A Croatian IT and telecommunicatios company launches Chatbot Solution

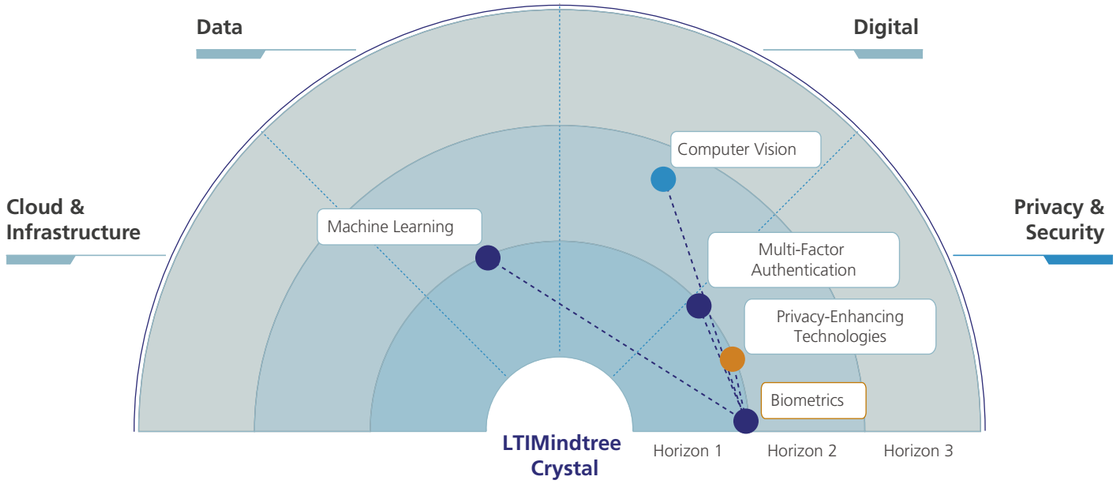
A Croatian IT and telecommunications company implemented its chatbot solution at a mobile telco operator groups in Africa. The African telco operator provides mobile network coverage and related technology services to more than 15 million subscribers. By deploying the Answers chatbot solution, were able to advance their customer engagement strategy and provide contextual support via automated communication. The solution will result in faster response times related to addressing basic queries and FAQs from customers, without the need to escalate these to the call center.

Biometrics – **Technology Landscape**(1/2)

Technology Rating

Horizon	Market Potential (USD)	Adoption Phase
Horizon 1	0-100Mn	Emerging
Horizon 2	100Mn-500Mn	Improving
Horizon 3	500Mn–1Bn	Mature
	1Bn–10Bn	
	10Bn +	

Crystal Positioning & Related Technologies



CRYSTAL **Insights**

Biometrics is one of the most implemented identities and access management methods across industries.

It is expected to continue to serve important functions in the future with its integration and collaboration with innovative technologies like **decentralized identity to make authentication methods more ubiquitous.**

Overview

Biometrics implementations are rising as an advanced layer to many **personal and enterprise security systems**. With the unique identifiers of your **biology and behaviors**, this may seem foolproof. Biometric technologies generally refer to the use of technology to identify a person based on some aspect of their biology. Biometric authentication is used in **computer science** as a form of identification and access control. It is also used to identify individuals in groups that are under surveillance. The use of biometric authentication solutions is on a rise than ever before and gaining attraction in **financial services, banking, travel & immigration, retail, healthcare, law, and biometrics for better security.**

Biometrics – **Technology Landscape**(2/2)

How is it a game changer?

Biometric technology has contributed to the fight against the **COVID-19 pandemic** and will do so in the future.

For both **private and business applications**, notably contactless biometrics, it has developed into the most practical security access control approach.

The healthcare sector has seen instances where **contactless biometrics** have saved the day by reducing the number of common touchpoints required for staff and patient authentication while also boosting security. The same holds true for **business locations and public safety.**

The new norms of **working from home, hybrid working, cloud kitchen, etc.,** were made easier by the combination of biometrics with cloud computing and web apps.

Additionally, with the advent of digital wallets and **biometric payment cards, cash transfers** have significantly decreased. Customer engagement can be improved by using biometric scanning, such as **iris recognition.** People prefer biometric payment cards and may even switch banks for these cards, which is fueling the contactless payment trend.

Key Use Cases

CPG & Retail

- Contactless hand-scanning payment system
- Facial recognition in stores to combat shoplifting and fraud

Life Sciences

- Protect patients' personal and sensitive information
- Multi-Factor Authentication for telemedicines

BFS

- Voice authentication to verify customers' identities
- Use fingerprints to authenticate transactions

Automotive

- Lock, unlock, and start vehicle using biometrics
- Eye tracking to prevent driver distraction and fatigue

Featured Story

Bank partners with a biometrics technology company for customer KYC

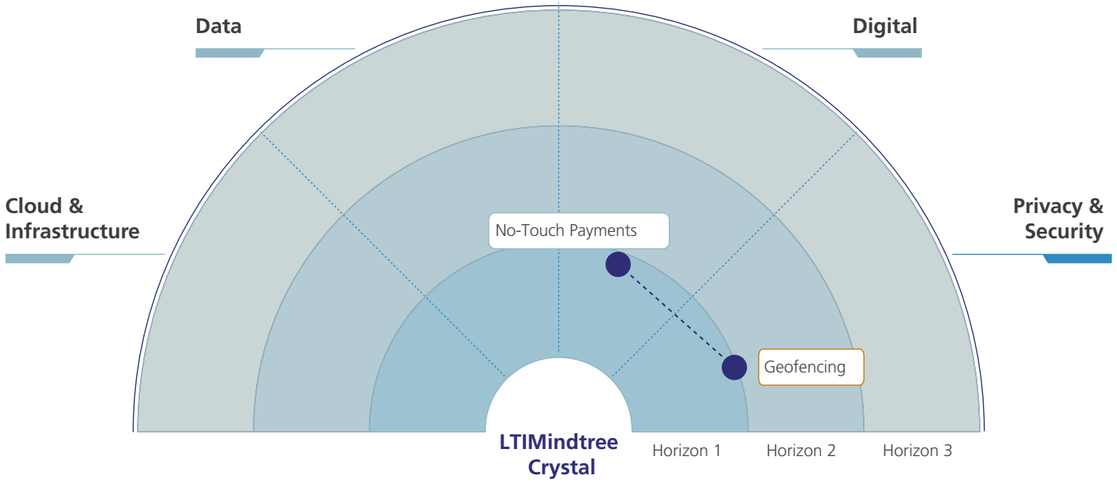
A Slovakia-based biometrics company partnered with a local **bank** to verify customers and perform KYC and AML processes with its AI-powered digital identity verification technology. This technology will enable bank customers to sign up by scanning their government-issued ID and uploading a selfie. Digital Onboardig Toolkit (DOT) will then compare the ID to the selfie with face biometrics and liveness detection to verify that it is the legitimate owner who is present.

Geofencing – **Technology Landscape**(1/2)

Technology Rating

Horizon	Market Potential (USD)	Adoption Phase
Horizon 1	0-100Mn	Emerging
Horizon 2	100Mn-500Mn	Improving
Horizon 3	500Mn–1Bn	Mature
	1Bn–10Bn	
	10Bn +	

Radar Positioning & Related Technologies



CRYSTAL **Insights**

Geofencing and location-based data gathering is a powerful technology that is leveraged by businesses of all sizes.

It is a **mature technology**, and its growing adoption is attributed to the businesses employing the technology to **drive conversion, increase customer loyalty and understand the behavior.**

Overview

Geofencing refers to a feature in software programs that use GPS (Global Positioning System) and RFID (Radio Frequency Identification) to establish a virtual geographic boundary. Entering or exiting this specific area can then trigger various pre-programmed responses or actions. Geofencing can be configured to prompt push notifications on mobile devices, send text messages, and alerts, deliver location-based marketing data and monitor activity in secure areas. However, there are privacy and security concerns about sharing location data via Geofencing. This has prompted many governments to enact consumer protection laws that regulate the use of location-based advertising.

Geofencing – **Technology Landscape**(2/2)

How is it a game changer?

While **Geofencing** is not a new technology, it has the potential to revolutionize mobile advertising strategies for companies. By leveraging the **location of devices connected to the internet**, Geofencing enables brands to create customized ads designed around customers' immediate circumstances.

When potential customer enters or exits the **virtual boundaries**, companies can target them with **personalized messages, discount offers, and promotions, providing an enhanced, omnichannel digital marketing experience**. Furthermore, companies gain an opportunity to **build brand loyalty** by assuring customers that their data will not be misused or sold.

Key Use Cases

Travel

Send alerts of reroutes or delays, inform drivers of a hailstorm headed their way, notify customers of a shuttle ETA

Retail

Send push notifications, alerts, and coupons, allowing real-time interaction with customers

Government

Protect access to government devices used by staff working remotely

Smart Homes

Control of household lighting, door locks, thermostats, electronic devices, burglar alarms, cameras, and fire and life safety devices

Featured Story

National Highway for Electric Vehicles (NHEV) ties up with a hyperlocal services andapplications provider to geofence an Indian E-highway

NHEV has tied up with several Geofencing tech companies to make the highway theft proof and under 24×7 breakdown service surveillance. The Indian national highway will be geofenced to allow electric vehicles on the route run on a theft-proof relay model. A similar model exists in Goa and several countries in Europe to enable tourists to get cars without any drivers. There is a next-gen smart micro-location and mapping platform, building the Internet of Places. This enables businesses to create Virtual Private Maps at the push of a button and tap into mapping, location and data tools to build highly scalable location-based application.

Multi-Factor Authentication (MFA) – **Technology Landscape(1/2)**

Technology Rating

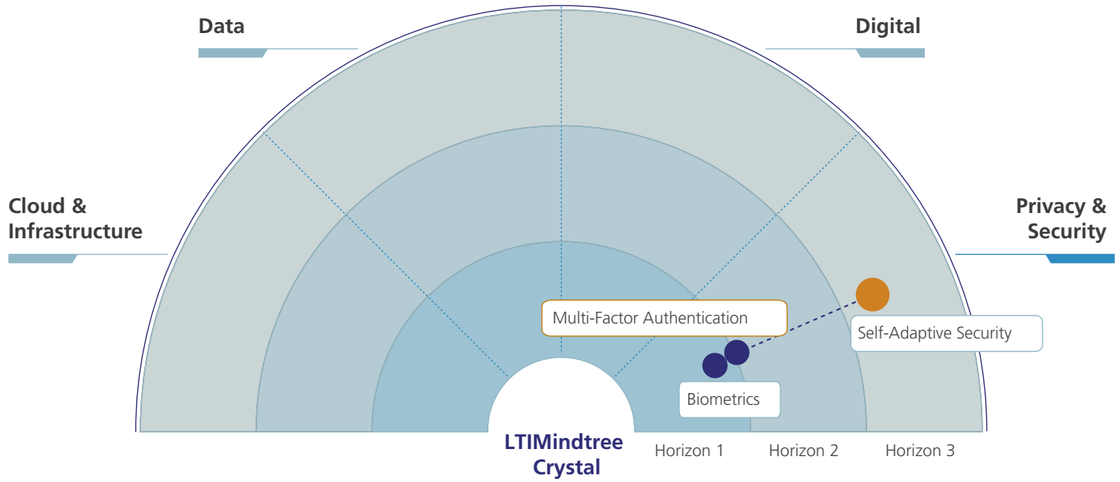
Horizon	Market Potential (USD)	Adoption Phase
Horizon 1	0-100Mn	Emerging
Horizon 2	100Mn-500Mn	Improving
Horizon 3	500Mn–1Bn	Mature
	1Bn–10Bn	
	10Bn +	

CRYSTAL **Insights**

MFA is a **widely used** method by **individuals and organizations** to secure their assets.

Advancements in next-generation MFAs using **Fast Identity Online(FIDO) & National Institute of Standard & Technology(NIST) certifications** to prevent hackers from exploiting loopholes will further propel the deployment of this technology.

Radar Positioning & Related Technologies



Overview

MFA is an electronic user identity validation system involving at least two different verification steps. MFA requires that identification credentials come from two different sources to **enhance security and prevent hacking**. These steps can range from verifying one's location on a **different device to using a fingerprint login**. Large tech companies have incorporated a variety of MFA strategies into their user operational models. However, the t**echnical complexity and high investment costs** associated with implementing MFA have limited the widespread adoption of this technology.

Back to Navigation

Multi-Factor Authentication (MFA) – **Technology Landscape**(2/2)

How is it a game changer?

Data security is one of the key challenges of the information age, especially with the upsurge in digital-first companies. Research by leading tech companies revealed that using MFA one can block up to **99.9% of account hacks.** This technology will shift from being a nice-to-have to an imperative feature of digital business models.

Expect gradual advances in MFA products in the coming years. Technology such as **PKI encryption that includes virtual smart cards could radically enhance the users' online security**.

Companies that are both transparent about how they use **data and have user-experience-friendly MFA strategies** will flourish, especially as businesses move from **brick-and-mortar to e-commerce**.

Large tech companies may begin acquiring **Virtual Card and Public Key Infrastructure (PKI)** businesses as part of their efforts to **prioritize data security** from both an operational and strategic perspective.

Recent use cases show that MFA is also being leveraged heavily by **government administrations** making the move towards **digitizing large quantities of sensitive data**.

Key Use Cases

BFS

Use of authentication apps for securing customer accounts

Use of voice print to access accounts

Retail

Combination of email-password and SMS for securing online accounts

Manufacturing

Use of 2-factor authentication for HMI/SCADA security

Life Sciences

NextGen healthcare login with two-step verification

Secure remote access to confidential health information

Featured Story

Identity assurance technology provider integrates with no-code identity orchestration service to provide best-in-class MFA

A provider of identity assurance technology integrated with an intelligent identity solution, leveraging the latter's no-code identity orchestration service. This partnership will enable their customers a unified identity experience across all engagement channels and throughout all stages of the customer's identity lifecycle expansive biometric authentication.

Back to Navigation

Privacy-Enhancing Technologies (PET) – **Technology Landscape(1/2)**

Technology Rating

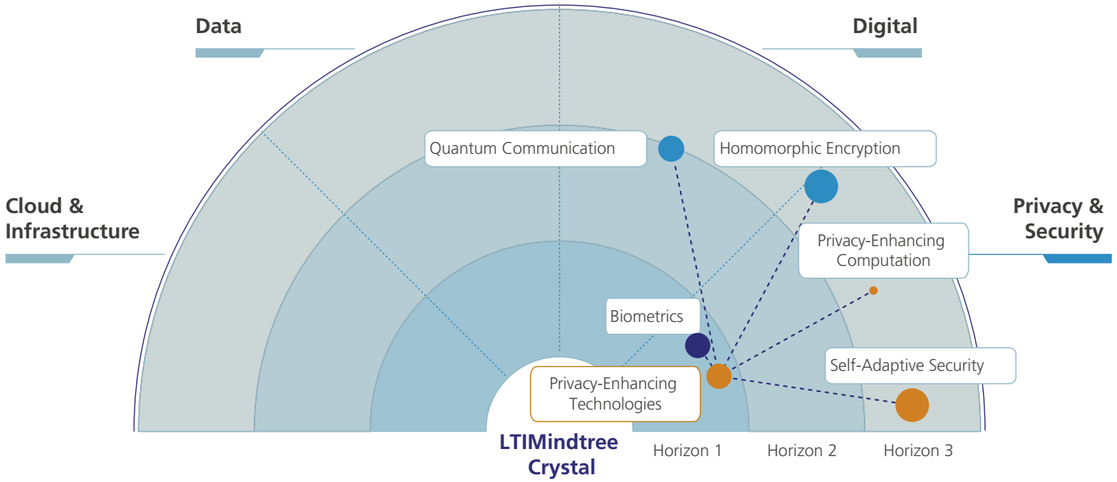
Horizon	Market Potential (USD)	Adoption Phase
Horizon 1	0-100Mn	Emerging
Horizon 2	100Mn-500Mn	Improving
Horizon 3	500Mn–1Bn	Mature
	1Bn–10Bn	
	10Bn +	

CRYSTAL **Insights**

Although there are successful and widely distributed use cases for PETs, the adoption of the technology is low.

The **growing awareness of digital identity and privacy risks** has enabled trends such as data ethics and data ownership. This has now led the businesses to prioritize PETs in their working models.

Radar Positioning & Related Technologies



Overview

Privacy-Enhancing Technologies (PETs) are measures that assist users in protecting their privacy. The need for PETs is becoming self-evident, with a growing number of recent cyber attacks and data breaches involving blue-chip tech companies. Examples of PETs include **advanced encryption, data masking, secure multiparty computation, and differential privacy.** PETs and their related technologies will allow companies and regulatory bodies to share data effectively without compromising the identity of individuals. Methods such as **federated analysis and homomorphic encryption** enable insight generation while protecting the source data.

Privacy-Enhancing Technologies (PET) – **Technology Landscape**(2/2)

How is it a game changer?

PETs and their related technologies will allow companies and **regulatory bodies to share data effectively without compromising the identity of individuals.**

Methods such as **federated analysis and homomorphic encryption** enable insight generation while protecting the source data. This creates new pathways to solve society's most pressing issues through ethical data usage.

PETs will help businesses to realize the value of collaborative data analytics while being compliant to strict privacy & security regulations. Cybersecurity is no longer a hygiene factor and business can no longer rely on physical boundaries and traditional perimeters to guard the company assets.

Technology is increasingly getting productized. It is also becoming specialized to cater to industry-specific use cases and dynamics. Similarly, interpretation of consumer privacy and the tradeoff between sharing information and service convenience needs to be carefully studied in context of industry.

Privacy preserving technology solutions continue to evolve to assist with not only readiness efforts, but also to automate portions of privacy management program once it's established.

Key Use Cases

BFS

Secure large-scale multi party financial transactions with Zero-Knowledge Proofs (ZKP)

Life Sciences

Safeguard sensitive patient information

Automate the discovery of patient data and identities

Media & Entertainment

Secure content exchange

Real-time strategy to classify sensitive content

Technology

Secure multi-party computation

Differential privacy

Featured Story

PETs startup bags USD 25 million investment

PET startup which has its roots at the US government's NSA, banked **USD 25 million** funding in a Series B round led by USAA with contributions from existing investors which include **Mastercard, Capital One Ventures,** C5 Capital, DataTribe, **In-Q-Tel,** Cyber Mentor Fund, Bloomberg Beta, GC&H, and 1843 Capital. The startup will leverage the capital to expand sales, product development, and marketing activity to capitalize on the accelerating market need to span global data silos and enable secure and private data usage, sharing, collaboration, and monetization. Investors continue to pour money into the PET space.

LTIMindtree

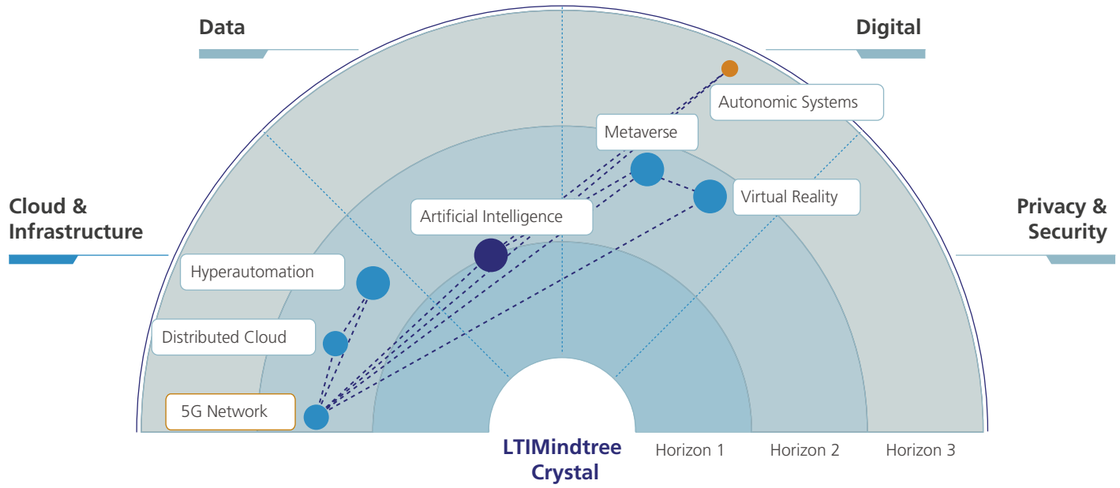
Horizon **2**

5G Network – **Technology Landscape**(1/2)

Technology Rating

Horizon	Market Potential (USD)	Adoption Phase
Horizon 1	0-100Mn	Emerging
Horizon 2	100Mn-500Mn	Improving
Horizon 3	500Mn–1Bn	Mature
	1Bn–10Bn	
	10Bn +	

Radar Positioning & Related Technologies



CRYSTAL **Insights**

5G subscriptions are expected to reach 1 billion by the end of 2022.

In several regions, **deployment of 5G standalone networks is picking up pace,** as communications service providers prepare for innovation to address the business opportunities beyond enhanced mobile broadband.

Overview

The 5th Generation Network (5G) is the latest global wireless standard after 1G, 2G, 3G, and 4G, which promises to connect virtually with everyone and everything. The 5G network is designed to **facilitate higher, multi-Gbps peak data speeds, low latency, increased reliability, increased network capacity,** and a more uniform user experience. The high spectrum prices that governments quote service providers–which would ultimately translate into high subscription prices for customers–could hinder the market growth of 5G technology.

5G Network – **Technology Landscape**(2/2)

How is it a game changer?

The widespread deployment of 5G will support the adoption and advancement of technologies like **telemedicine, AI-enabled customer service, precision agriculture, autonomous vehicles**, etc.

The technology could impact various sectors including education, video surveillance, virtual & augmented reality, agriculture, urban infrastructure, and health, facilitating increased democratization and flexibility.

Dedicated **private 4G/ 5G networks** are already being deployed in proof-of-concept trials to validate the value of new services.

A 5G network allows for enhanced synchronization across different systems. For efficient performance of business operations virtually, high-speed data storage and transfer capabilities are essential. 5G technology is an effective solution to the latency issues encountered by enterprises today.

Key Use Cases

Technology

Reduced latency, as transmission channel will be able to respond 10-100 times faster than over current cellular networks

Manufacturing

Smart factories and logistics

Enabling remote monitoring of production assets

Oil & Gas

Ultra-high speed and low latency communication between drilling sites, vessels, and offshore platforms

Life Sciences

Connected ambulances

AR/VR assistance for the blind

Better telemedicine services

Featured Story

More than 170 commercial 5G agreements or contracts with unique operators

A Swedish multinational networking and telecommunications company is the first company to bring 5G to four continents, as well as the IoT, edge computing, and cloud network infrastructure. The company's portfolio is based on transformation and innovation, paving the way for a fully connected world. Its Radio System enables operators to quickly launch new technology and expand 5G coverage, regardless of scale or complexity, and the spectrum sharing enables accelerated 5G rollouts using existing hardware.

Distributed Cloud – **Technology Landscape(1/2)**

Technology Rating

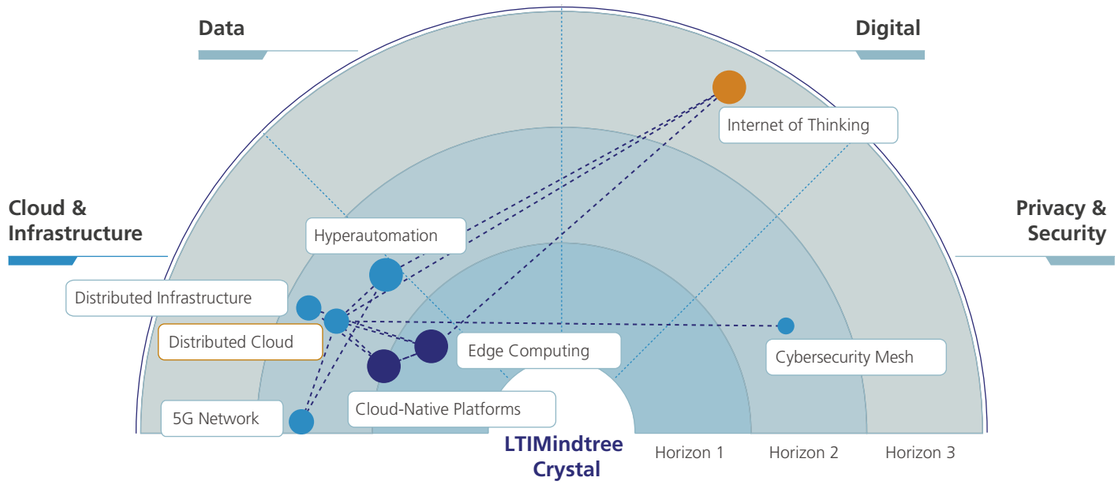
Horizon	Market Potential (USD)	Adoption Phase
Horizon 1	0-100Mn	Emerging
Horizon 2	100Mn-500Mn	Improving
Horizon 3	500Mn–1Bn	Mature
	1Bn–10Bn	
	10Bn +	

CRYSTAL **Insights**

Distributed Cloud is an improving technology and its growth is attributed to the rise in **IoT, edge applications and multi-cloud computing.**

However, secure and reliable connectivity between the cloud providers in a **multi-cloud** scenario remains a concern and is holding back its widespread adoption.

Radar Positioning & Related Technologies



Overview

Distributed Cloud refers to the next generation of cloud computing, in which resources like computing power, storage, and microservices are accessed on-demand instead of being managed by the user. Distributed Cloud leverages a variety of cloud "locations," including public clouds, private clouds, and on-premises infrastructure. This means organizations have greater flexibility in how they **deploy software, optimize performance, regulatory compliance, data security, and more.**

Distributed Cloud – **Technology Landscape**(2/2)

How is it a game changer?

Distributed Cloud architecture will disrupt multiple industry sectors including **healthcare, transportation, logistics, manufacturing, construction, and retail**. For fleet management, systems located within regional clouds can analyze data from multiple vehicles to optimize navigation with minimal latency.

Moreover, with the growing implementation of IoT and other data-intensive systems, Distributed Cloud will enable efficient end-to-end management, optimizing data management, computing speeds, and network connectivity. It will also be significant in determining how 5G networks are designed and deployed.

Key Use Cases

BFS

Cross channel banking experience consolidation

Automotive

Capturing data in real time to make instant decisions for autonomous or self-driving vehicles

Technology

Allows the data to move faster due to the physical proximity of the distributed data center

Featured Story

Cloud giant partners with German telecom to offer distributed cloud for telecom industry

A German telecom giant and a cloud leader announced partnership to define a joint road map for the telecommunications industry, by bringing the power of the cloud closer to mobile and connected devices at the edge of the network.

Under this collaboration the companies will jointly pilot several network services such as 5G Standalone in Austria, as well as remote packet gateway functions, leveraging the cloud vendor's cloud and distributed cloud edge, a fully managed product that brings the cloud infrastructure and services closer to where data is being generated and consumed.

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Distributed Infrastructure – **Technology Landscape(1/2)**

Technology Rating

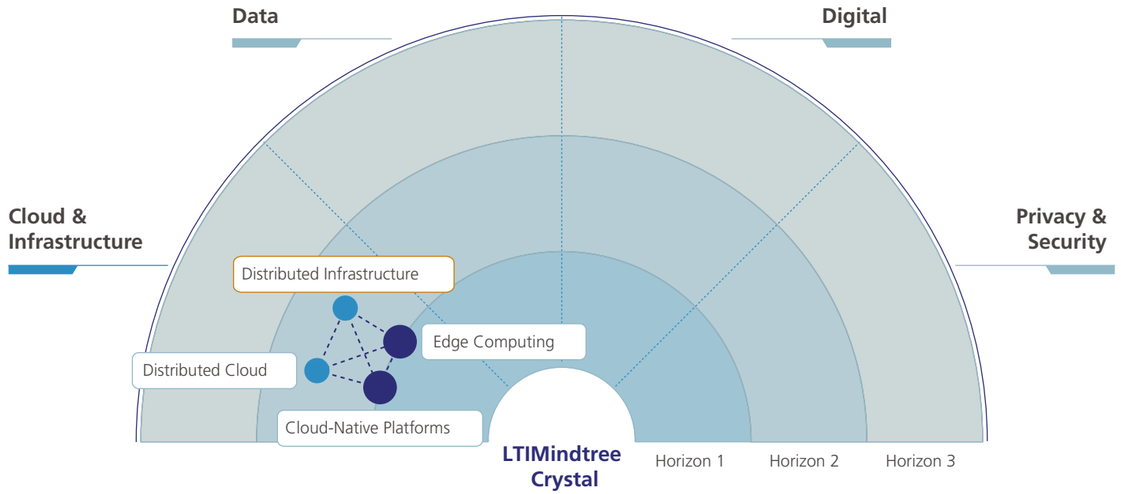
Horizon	Market Potential (USD)	Adoption Phase
Horizon 1	0-100Mn	Emerging
Horizon 2	100Mn-500Mn	Improving
Horizon 3	500Mn–1Bn	Mature
	1Bn–10Bn	
	10Bn +	

CRYSTAL **Insights**

Distributed Infrastructure is an improving technology, and its growth is attributed to the **flexibility and scalability** it offers.

The growth in **smart grids, smart factories, and IoT solutions** will drive the demand for Distributed Infrastructure for real-time management and to gain control at the edge in the near future.

Radar Positioning & Related Technologies



Overview

Distributed Infrastructure is the way IT organizations ensure applications are always deployed to provide best performance and scalability. In fact, modern infrastructure tools such as **containers and APIs** have opened many new architecture possibilities. This even includes spanning applications over on-premises data centers, public cloud, and edge locations. However, this amount of infrastructure flexibility introduces new IT management challenges. It is suggested that, Distributed Infrastructure management should be unified and centrally visible.

Distributed Infrastructure – **Technology Landscape**(2/2)

How is it a game changer?

Distributed Infrastructure systems can be leveraged to create distributed programs, without first having to comprehend the underlying mechanics. It enables users to take full advantage of the speed and storage capacity of high-speed computing clusters.

Distributed file systems are designed to be deployed in low-cost hardware and have high fault tolerance. These systems are widely used in data mining, log analysis, advertising computing and web search fields.

Distributed Infrastructure systems are receiving attention from open-source projects, as they are increasingly focusing on distributed computing. Moreover, this technology has been implemented by recognized companies including IBM, Amazon, Facebook, Yahoo for distributed computing.

Key Use Cases

Government

Distributed and scalable framework for smart cities

Real-time complex data-based decision making

Energy

Real-time simulations in smart grids leading to better predictability and efficient power consumption

Manufacturing

Data intensive & complex use cases for Industry 4.0

Distributed data storage

Automotive

Creation and distribution of advanced maps with real-time data

Vehicle On-board diagnostics (OBD) integration

Featured Story

A German multinational and a geographic information system software provider partner to bring grid planning and operation to a new level

A German multinational partnered with a provider of geographic information systems (GIS) and location intelligence, to expand its ecosystem of partners for its grid software business. The partnership enhances capabilities for the planning, operations and maintenance of power networks at grid operators by combining GIS vendor's powerful mapping and spatial analytics software and the tech giants' electrical topology expertise. The companies are aiming to upgrade the data flow between applications for increased planning accuracy and for better operations of the distribution grid. Their objective is to improve the admission of Distributed Energy Resources (DER) to the grid and thereby expedite net zero.

Hyperautomation - **Technology Landscape(1/2)**

Technology Rating

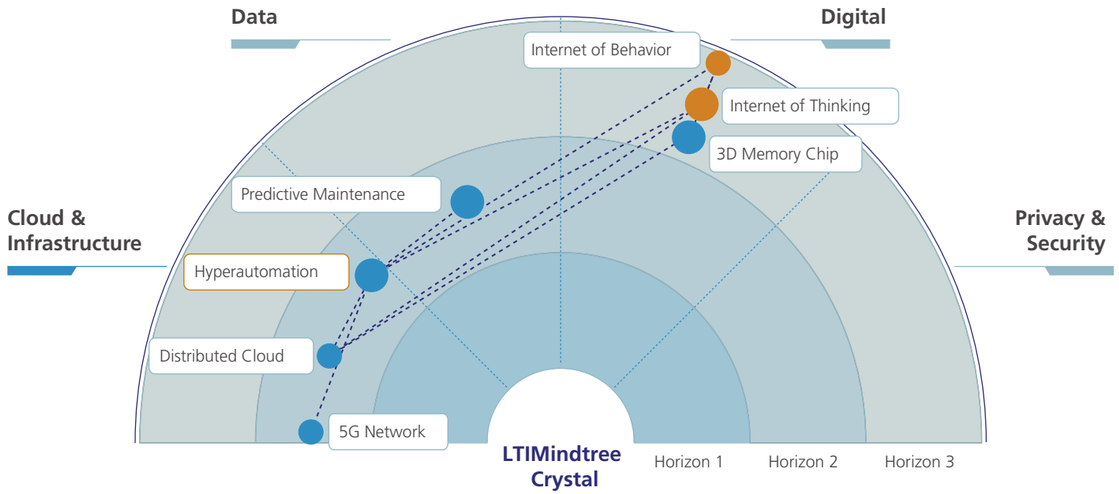
Horizon	Market Potential (USD)	Adoption Phase
Horizon 1	0-100Mn	Emerging
Horizon 2	100Mn-500Mn	Improving
Horizon 3	500Mn–1Bn	Mature
	1Bn–10Bn	
	10Bn +	

CRYSTAL **Insights**

Evolution in **AI, ML and RPA** are improving the capabilities of hyperautomation and expanding its applications in **healthcare, supply chain and banking & finance sectors.**

According to Gartner, companies using hyperuatomation can **reduce operational costs by 30% within 4 years.** This will attract investments in hyperautomation from all types of organizations.

Radar Positioning & Related Technologies



Overview

A **business-driven** approach to identify, vet and automate as many business and IT processes as possible. It requires the **orchestrated use** of multiple technology tools and platforms, including **RPA, low-code platforms**, and **process mining tools**. The bots that will be designed by hyper-automation will improve accuracy and productivity to improve the entire business process. Increased focus on growth, digitalization, and operational excellence have highlighted a need for better, more widespread automation.

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Hyperautomation - **Technology Landscape**(2/2)

How is it a game changer?

According to a study by **McKinsey**, respondents indicated that their companies were able to adopt to **digital changes at least by 25 times** faster and remote working solutions were implemented 40 times faster, than they would have expected in the pre-pandemic condition.

A study conducted on the **US health industry** states that, "collectively, the **industry spends nearly USD 2.1 billion annually** on poorly performed and error-prone manual tasks on provider data management alone". Since it involves high cost , there is an immediate need for hyperautomation.

A few healthcare clinics have already begun **utilizing Digital Nurse Avatars to talk to patients**, as the first line of help. These Digital Nurses pose important inquiries about their well-being and symptoms to appropriately help them with further diagnosis and help them reach the appropriate medical centers.

Key Use Cases

BFS

Auto-classification and indexation of documents

Life Sciences

Manage supply chain / drug inventory and procurement

Insurance

Automating compliance checks & data validation for quicker claims processing

Retail

AI-assisted loyalty recognition methods

Automated check-outs

Featured Story

Hyperautomation platform for employee and customer experiences launched by UK Hyperautomation pioneer

UK hyperautomation provider has launched its new enterprise-scale platform, which is capable of bolstering customer and employee digital experiences. Their advanced HyperAutomation platform's totally unique architecture makes it the only way of liberating enterprises from the constraints of legacy IT environments, their manual, paper-heavy processes, and the complexity and cost of digitizing their entire end-to-end services.

Decision Intelligence (DI) – **Technology Landscape(1/2)**

Technology Rating

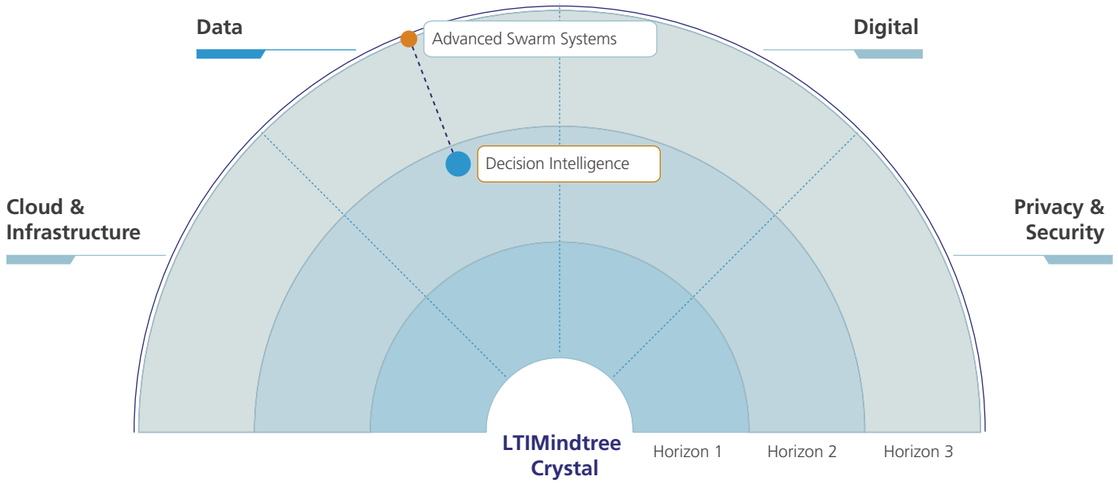
Horizon	Market Potential (USD)	Adoption Phase
Horizon 1	0-100Mn	Emerging
Horizon 2	100Mn-500Mn	Improving
Horizon 3	500Mn–1Bn	Mature
	1Bn–10Bn	
	10Bn +	

CRYSTAL **Insights**

Though implementation is still in the **early stages**, decision intelligence platforms are being used by organizations to help **automate and accelerate decision-making** in a variety of industries and use cases.

With decision intelligence tools CTOs can support business strategy by identifying how AI can help with achieving KPIs. CTOs who already have access to data can use AI to gain competitive edge through an action focused route.

Radar Positioning & Related Technologies



Overview

Decision Intelligence is the application of **machine learning and automation** to augment human decision-making for better, faster insights-driven business decisions. To accomplish this, decision intelligence equips anyone to ask and answer what, why, and how-type questions of unaggregated data to drastically reduce the time and effort necessary to make strategic, tactical, and operational decisions.

Decision Intelligence (DI) – **Technology Landscape**(2/2)

How is it a game changer?

Gartner has identified Decision Intelligence as a top strategic technology trend for 2022 and predicts that in the next two years, a third of large organizations will be using DI for structured decision-making, to **improve competitive advantage.**

As the volume of data created throughout the enterprise continues to increase and data pipelines are optimized to enable organizations to make decisions and act in real-time, DI will become the critical link between massive amounts of data, real-time contextual insight, recommendations and decision-making.

In the era of cloud-scale data, the bottleneck in analytics has shifted from aggregating, accessing and processing data to enabling everyone in an organization to leverage all that collected information and make decisions.

With BI tools today, business users struggle to get the contextualized insights they need at the point of decision, so they either give up or go with their gut. **DI will become a major competitive differentiator among data-driven companies** from financial services to health-care, supply chain, e-commerce & retail and manufacturing to solve the "last mile of analytics" challenge."

Key Use Cases

BFS

Risk management

Assist customers to make wiser invest-ments

Study customer behaviour

Manufacturing

Smart manufacturing - Reduce wastage by increased efficiency and positively impacting carbon footprint

Supply Chain & Logistics

Improve inventory management to avoid overstocking

Retail

Serve right recommendations, at the right time, via the right channel to customers

Featured Story

Decision Intelligence to cut climate risks

A US based decision intelligence startup is helping energy infrastructure companies prevent fires, outages, explosions and worker accidents. Climate change has increased the risk to electrical grids and other infrastructure as extreme heat and cold overwhelm capacity and damage equipment. The startup combines environmental and infrastructure data to foresee and head off from incidents ranging from storms to excavations.

Predictive Maintenance – **Technology Landscape(1/2)**

Technology Rating

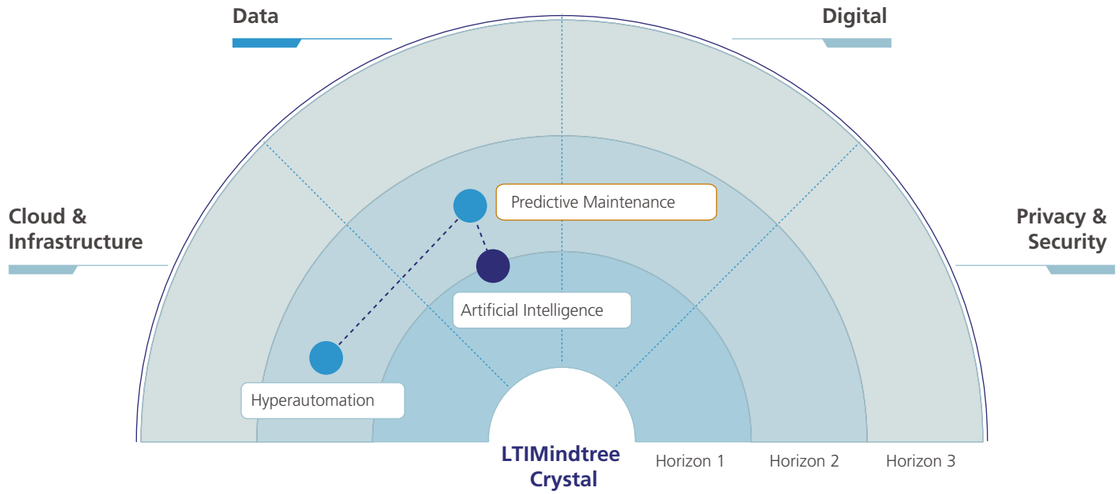
Horizon	Market Potential (USD)	Adoption Phase
Horizon 1	0-100Mn	Emerging
Horizon 2	100Mn-500Mn	Improving
Horizon 3	500Mn–1Bn	Mature
	1Bn–10Bn	
	10Bn +	

CRYSTAL **Insights**

Predictive Maintenance solutions are evolving with the quality of data that can be harnessed from assets improving dramatically.

Adoption of IoT and integration of AI and ML technologies with predictive maintenance software to minimize maintenance costs and downtimes will further drive the adoption of this technology.

Radar Positioning & Related Technologies



Overview

Predictive Maintenance (PdM) is a system that uses condition-monitoring techniques and predictive analytics to **detect anomalies in machine** operation and flag issues before they result in failure. This is achieved through the **real-time evaluation of data** received from smart sensors and IoT-connected machines. This AI-based predictive model minimizes machine downtime, saving costs and maximizing equipment lifespan. Current challenges to adoption include the high initial investment required and the relative immaturity of IoT technology.

Predictive Maintenance – **Technology Landscape**(2/2)

How is it a game changer?

The switch from reactive to **predictive maintenance** will disrupt production, service, and delivery. Cloud-based **software and machine learning** will expand capabilities to deliver insights that make systems more effective and efficient.

With the evolution of 'Industry 4.0' in the manufacturing sector, the integration of IIoT will further enable Predictive Maintenance adoption. Leading automobile companies have already started using microbots for vehicle maintenance in the automotive sector.

Enterprise business intelligence solution also allows them to predict asset failure or quality issues to avoid costly downtime and reduce maintenance costs. This early **identification of potential concerns** helps to deploy limited resources more cost-effectively, maximize equipment uptime and **enhance quality and supply chain processes**, ultimately improving customer satisfaction.

Business intelligence & analytics solutions also provides advanced **visualization and self-service interactive interfaces** for easy adoption by business users.

Key Use Cases

Manufacturing

- Predicting machine failure
- Plant maintenance schedule ensuring right engineers and equipment are available

Oil & Gas

- Oil & Gas pump condition monitoring
- Tank pressure monitoring
- Drill corrosion detection and maintenance

Life Sciences

- Detect signs of impending failure of critical equipment in hospitals

Transportation

- Predict vehicle breakdown in advance

Featured Story

Global power management and industrial automation company minimizes costs and worker risk with Azure Machine Learning service Predictive Maintenance

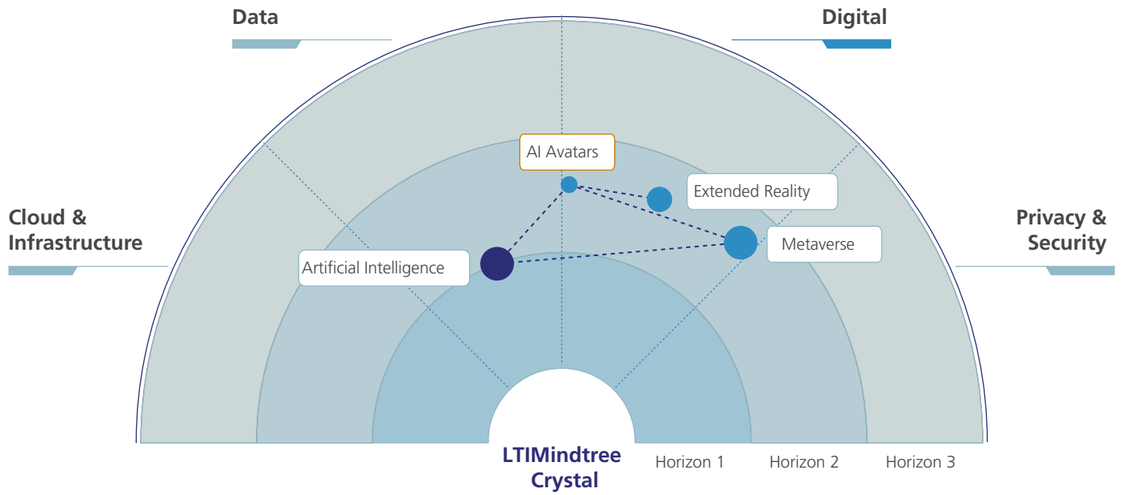
Global power management and industrial automation company developed Realift Rod Pump Control, a predictive IoT analytics solution based on Microsoft Azure Machine Learning service and Azure IoT Edge. Oil and gas producers use it to pinpoint which remote equipment needs repair, achieving substantial savings on maintenance, optimizing production and profit, and increasing safety for workers and the environment.

AI Avatars – **Technology Landscape**(1/2)

Technology Rating

Horizon	Market Potential (USD)	Adoption Phase
Horizon 1	0-100Mn	Emerging
Horizon 2	100Mn-500Mn	Improving
Horizon 3	500Mn–1Bn	Mature
	1Bn–10Bn	
	10Bn +	

Radar Positioning & Related Technologies



CRYSTAL Insights

Major driving factors to contribute to revenue growth of AI Avatars include the **rapidly growing efforts to build immersive gaming experiences, an increasing number of contact centers, increasing virtual corporate setups.**

With metaverse going live in the virtual world, will increase the adoption of AI Avatars in future.

Overview

AI Avatars are digital bots that use voice interfaces, **Natural Language Processing (NLP) algorithms**, and deep learning to emulate human characteristics. As AI Avatars grow more human-like and intelligent—as the underlying technology and machine learning algorithms advance—companies are harnessing their capabilities to deliver enhanced, personalized service 24/7 at a reduced cost. Limitations include a loss of real **human connection, displacement of jobs, and negative associations with deep-fake technology**.

Back to Navigation

AI Avatars – **Technology Landscape**(2/2)

How is it a game changer?

As the underlying technology advances, AI Avatars will become increasingly fit-for-purpose and ubiquitous in everyday interactions between organizations and people. Their use in customer-facing, instructional & assistant positions will expand, resulting in younger generations with new heightened service and information delivery expectations. As the gaming industry continues to grow, AI Avatars emerge as a form of self-expression in the always-on metaverse.

AI Avatars, through use of **AI technology**, is witnessing increasing use in **healthcare** and other industries. Although, use of AI in healthcare can provide solutions for scalability, cost reduction, and convenience, only AI Avatars can establish **real-time and dynamic integrations with patients**.

However, concerns around the unethical use of AI Avatars and deepfake technology persist and must be addressed by policy-makers.

Key Use Cases

Media & Entertainment

Improving human-like interaction by using AI avatars as virtual assistants in gaming

Retail

Hyper-personalized in-store retail experience

Up-Skilling

Continuous learning and engagement in classroom trainings through AI avatars

BFS

On-demand personalized banking assistance

eKYC with the help of avatars

Featured Story

A US based multinational's omniverse avatar solution enables real-time conversational AI assistants

A US based multinational's omniverse Avatar solution integrates the company's speech AI, computer vision, natural language understanding, recommendation engines, and simulation technologies. Avatars created in the platform are interactive characters with ray-traced 3D graphics that can see, speak, converse, and understand naturally spoken intent. These could aid in the billions of daily customer service interactions — restaurant orders, banking transactions, personal appointments and reservations, and so on — resulting in increased business opportunities and improved customer satisfaction.

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API Economy – **Technology Landscape(1/2)**

Technology Rating

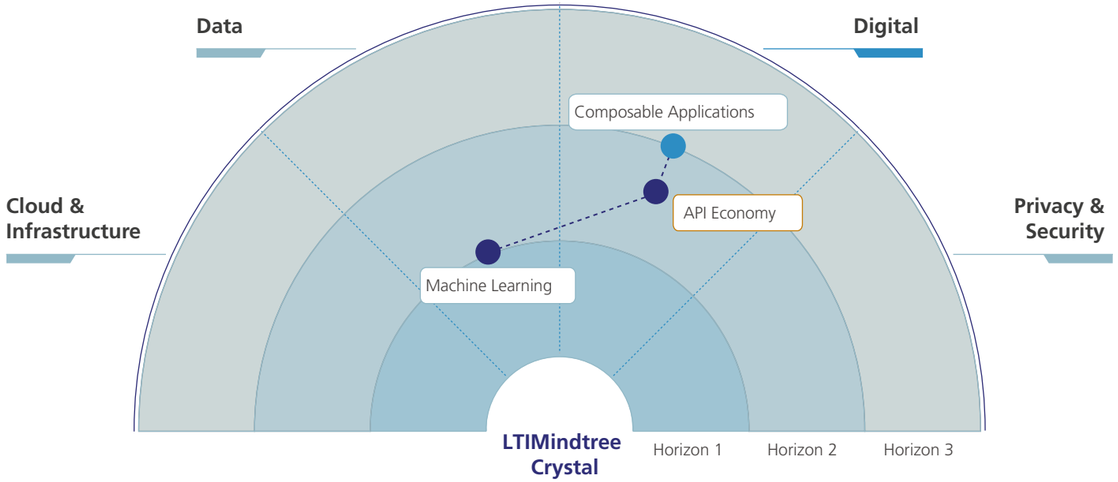
Horizon	Market Potential (USD)	Adoption Phase
Horizon 1	0-100Mn	Emerging
Horizon 2	100Mn-500Mn	Improving
Horizon 3	500Mn–1Bn	Mature
	1Bn–10Bn	
	10Bn +	

CRYSTAL **Insights**

API Economy is at a **mature stage**. AI is transforming API management by improving efficiency and securty.

In addition, regulatory bodies are focusing on introducing stringent **API security standards** to ensure essential financial-grade security. This is increasing its adoption in **open-banking applications.**

Radar Positioning & Related Technologies



Overview

The **API Economy** is a business model built around the use of APIs in the digital economy. APIs refers to application programming interfaces made available to third-party data and services. APIs work as a bridge to connect data extracted from one software application to the next application securely and accurately so that the two can communicate and share data seamlessly. The API Economy is vital because it creates **new business models** and allows companies to profit by selling their features as **Software-as-a-Service (SaaS)** products.

API Economy – **Technology Landscape**(2/2)

How is it a game changer?

The API Economy allows for product optimization collaboration between developers and API providers. This collaboration leads to better digital products and creates new income streams for software companies in a time of mass digital service proliferation. This technology also influences the **IoT** ecosystem where instead of building APIs from scratch developers can now combine APIs from various sources, creating the type of interoperability that IoT is designed for.

Research shows that businesses using API as a conduit for conducting business, experienced a net revenue **growth of 30%** while those who use APIs more extensively both internally and with outside developers **report time (and cost) to market reductions of up to 90%.**

Companies are focusing on developing models in which APIs are used to leverage greater equity of opportunity rather than businesses seeing a narrow API call monetization opportunity.

Key Use Cases

Travel & Transport

Show best airline and hotel deals on travel aggregator sites

CPG & Retail

Amalgamating data to achieve omnichannel commerce

Automotive

Car manufacturers use APIs to send software updates to their vehicles

BFS

Use Google Maps API to provide "branch locator" functionality for website or app

Improve collaboration between banks, insurance companies, and other financial services

Featured Story

A multinational retailer added several API partners to its retail media network

A US based multinational retailer recently added new features and self-service capabilities to its growing retail media platformin order to stay ahead in a competitive environment and to meet strong interest from brands in leveraging retailers' data to optimize their marketing efforts. The company has network total 14 API partners specialized in a combination of e-commerce ads, ad optimization and cross-channel advertising.

Augmented Reality (AR) – **Technology Landscape(1/2)**

Technology Rating

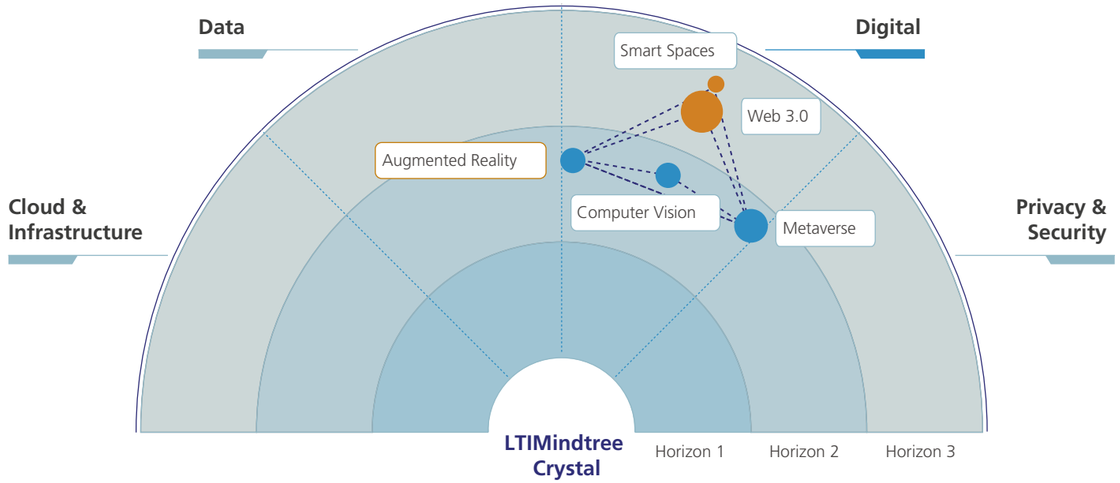
Horizon	Market Potential (USD)	Adoption Phase
Horizon 1	0-100Mn	Emerging
Horizon 2	100Mn-500Mn	Improving
Horizon 3	500Mn–1Bn	Mature
	1Bn–10Bn	
	10Bn +	

CRYSTAL **Insights**

In 2020 and 2021, AR observed intensive growth and is expected to continue its growth with rising applications in the enterprise as well as consumer use cases.

Several innovative projects have shown that AR has a good commercial value which is attracting start-ups as well as established players to invest in this technology.

Radar Positioning & Related Technologies



Overview

Augmented Reality (AR) is an **interactive experience** of a real-world environment where the objects that reside in the real world are enhanced by **computer-generated perceptual information**, sometimes across **multiple sensory modalities**, including **visual, auditory, haptic, somatosensory, and olfactory**. With each sector getting explored with the fullest scope of implementing AR technology. From retail businesses to health sectors, AR has helped in every way which makes the processes of these sectors. AR is being used in a vast variety of industries worldwide including **eCommerce, gaming, education, training, medical, construction, and marketing.**

Augmented Reality (AR) – **Technology Landscape**(2/2)

How is it a game changer?

AR which is frequently associated with gaming has the potential to revolutionize operations in a variety of industries, including **automotive, healthcare, manufacturing, retail, real estate, and others.**

During the **COVID-19 pandemic**, when national lockdowns and restrictions confined us all to our homes, the only escape was a quick trip to the grocery store, a neighborhood walk, or a visit to the doctor's office. Despite these challenges, **AR/VR technology** has allowed people all over the world to visit new countries, cities, museums, and restaurants from the comfort of their own homes.

According to one of the hyperscalers, companies that use AR have reported a **46% reduction in time** to complete tasks and a **32% increase in average productivity.**

In an experiment, **a French wind turbine maker** compared the use of AR smart glasses with the standard procedure of **wiring insertion** for a wind turbine by following paper instructions. When adopting AR technology for the assignment, the technician's productivity increased by **34.5 %** right away.

Key Use Cases

Manufacturing

- Troubleshooting high-end machinery
- Real-time employee instruction and education

Automotive

- Driver safety management
- Performance of repair and remote maintenance work

CPG & Retail

- Virtual try-on of products
- Make-up styling
- Creation of AR-based store-like experience

Life Sciences

- Advanced diagnostics and risk assessment
- Description of patients' symptoms
- Augmented surgery

Featured Story

German automaker to bring Augmented Reality to cars

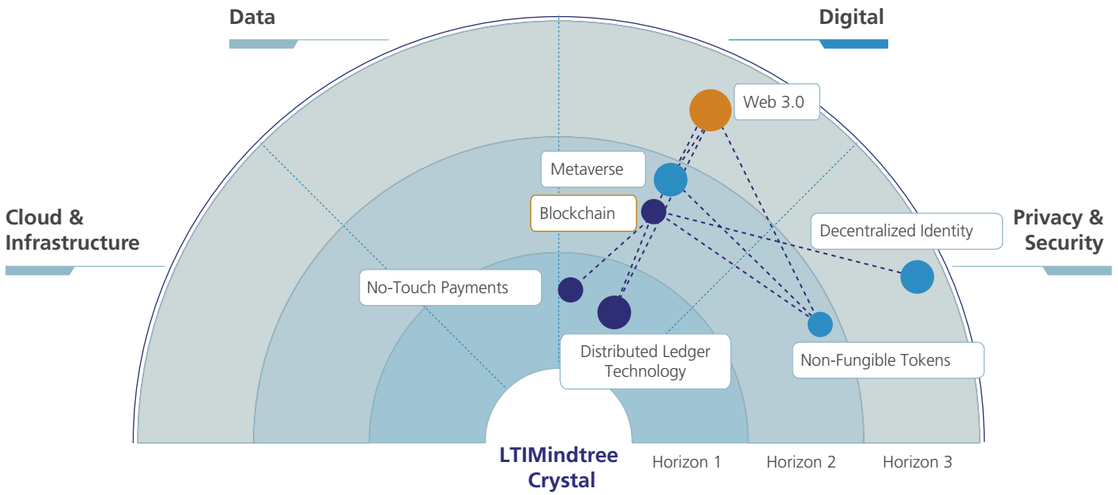
One of the recognized German automakers partnered with a Mixed Reality solutions provider to bring **Augmented Reality** into **cars** using Mixed Reality sunglass. Both the companies have been experimenting with Mixed Reality sunglasses in **moving vehicles** and they have created a **'moving platform'** model for the working of the headset. The 'moving platform' for Mixed Reality sunglasses overcomes some major limitations of **VR headsets and creates new potential like-training drivers to handle challenging road conditions and developing new scenarios for autonomous vehicles.**

Blockchain – **Technology Landscape**(1/2)

Technology Rating

Horizon	Market Potential (USD)	Adoption Phase
Horizon 1	0-100Mn	Emerging
Horizon 2	100Mn-500Mn	Improving
Horizon 3	500Mn–1Bn	Mature
	1Bn–10Bn	
	10Bn +	

Radar Positioning & Related Technologies



CRYSTAL **Insights**

The adoption of blockchain among the governments is rising. However, many **governments are still trying to deal with the challenge of trust.**

Another area that is driving the adoption of blockchain is cryptocurrencies.

Overview

Blockchain is a **decentralized, distributed, immutable ledger** that facilitates the process of **recording transactions and tracking assets** in a network. A blockchain collects information together in groups, known as **blocks, that hold sets of information**. By inherent design, the data on a blockchain is unable to be modified, which makes it a legitimate disruptor for industries like **payments, cybersecurity and healthcare. Virtually** anything of value can be tracked and traded on a blockchain network, reducing risk and cutting costs for all involved.

Blockchain – **Technology Landscape**(2/2)

How is it a game changer?

With so many experiments taking place through **legacy** as well as **new-age businesses, stakeholders** in all these industries are certainly looking forward to integrating **blockchain** into their core processes.

Distributed ledger technology, especially Blockchain, is not only revolutionizing the currency world but also creating a more **transparent financial system**.

Even though the tech is yet to deliver concrete results in many cases, the enthusiasm amongst **engineers, developers, and industry stakeholders** are at an all-time high. The future of blockchain is not going to be limited to cryptocurrencies.

Even though the crypto market will grow several folds, there will be new opportunities for blockchain developers in some very exciting fields such as **digital advertising, supply chain management**, etc.

Originally blockchain was introduced for Bitcoin **electronic cash system**, however, with advancements and level of security, it is expanding its applications in **government, healthcare, law, insurance, real estate and gaming industries.**

Key Use Cases

BFS

- Payments between individuals and businesses
- Facilitate interbank settlement

Government

- Secure storage of government, citizen, and business data
- Reduced potential for corruption and abuse

Media & Entertainment

- Peer-to-peer sales and content distribution
- Streamlined royalty payments
- Usage-based billing models

Life Sciences

- Secure management of electronic health records
- Create private network to trace and track events in the pharmaceutical supply chain

Featured Story

Kenya's secure blockchain-driven health platform launches blockchain patient portal in South Africa

A Kenyan e-health start-up has launched its fully automated universal patient portal in South Africa, vowing to change the face of patient care across the country, Africa and the world. Using block-chain driven technology, the universal patient portal is described as a secure central, mobile platform where patients and the medical professionals treating them have real-time access to their health data and medical history. This not only ensures effective ongoing medical management, but critical, timely information in an emergency.

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Composable Applications – **Technology Landscape(1/2)**

Technology Rating

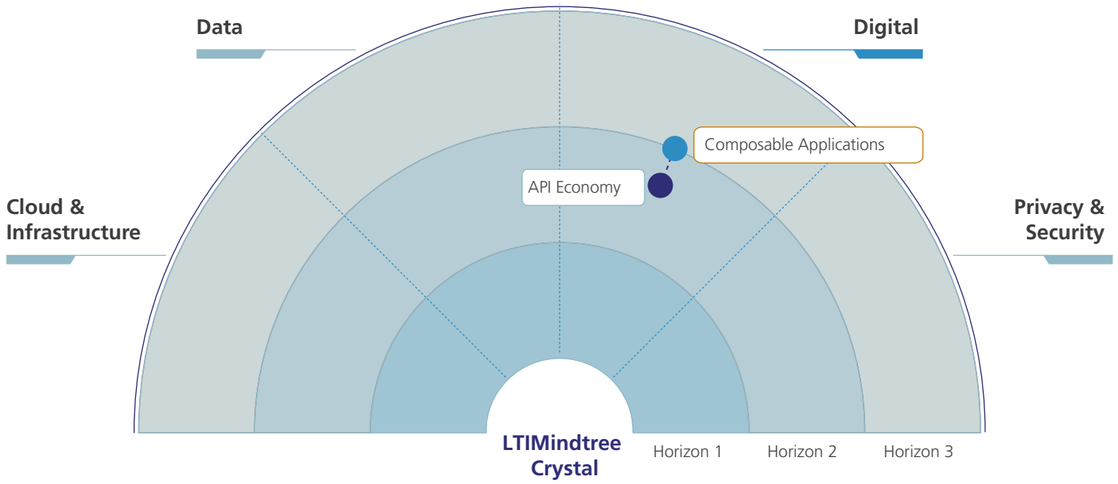
Horizon	Market Potential (USD)	Adoption Phase
Horizon 1	0-100Mn	Emerging
Horizon 2	100Mn-500Mn	Improving
Horizon 3	500Mn–1Bn	Mature
	1Bn–10Bn	
	10Bn +	

CRYSTAL **Insights**

Composable Applications are bringing new opportunities to enterprises in the healthcare, and manufacturing sectors to improve their productivity and speed along with service delivery

Businesses are committing to composable applications in order **to reduce deployment costs and faster Go-to-Market.**

Radar Positioning & Related Technologies



Overview

Composable Applications are made up of **packaged-business capabilities (PBCs) or software-defined business objects.** PBCs for example representing a patient or digital twin, create reusable modules that fusion teams can self-assemble to rapidly create applications, reducing time to market, help businesses to understand technology solutions and guide them through a process of ever-changing business requirements. The goal is to build a collaborative architecture that independently attaches to and connects with **APIs** that interact with each other. Composable applications enable businesses to be **proactive, build, deploy and adapt** to change quicker than ever before.

Composable Applications – **Technology Landscape**(2/2)

How is it a game changer?

The 2020 pandemic specifically showed that organizations aiming to survive extreme market changes must expand today's most valuable efforts and down-size their dated areas without delay.

From reusable block-like **microservices to cross-application connection points,** code that's openly adjustable permits this composability more easily than legacy applications. By adding in **low-code architecture,** enterprises have the flexibility needed to meet even the most urgent changes across markets and industries globally.

This composability allows organizations to combine different modular applications in an **incremental and agile** way through rapid sprints instead of embarking on **time-consuming and costly rip-and-replace projects.**

Therefore, reach faster impact regardless of where manufacturers might be in their **digital supply chain transformation** journey. In addition, they support innovative features such as **predictive analytics or agile manufacturing for real-time and cross-channel inventory visibility.**

Key Use Cases

BFS

- Build customer engagement portals
- Use low-code to develop own API-inundated platforms

Automotive

- End-to-end visibility to scale supply chain networks
- Digital transformation of order management process

CPG & Retail

- Create an agile retail ecosystem
- Reduce friction in customer interaction

Life Sciences

- Mobile health application development
- Develop integrated patient portal to provide post-visit care to patients

Featured Story

Southeast Asia's bank to use AI-driven composable platform to empower staff and delight customers

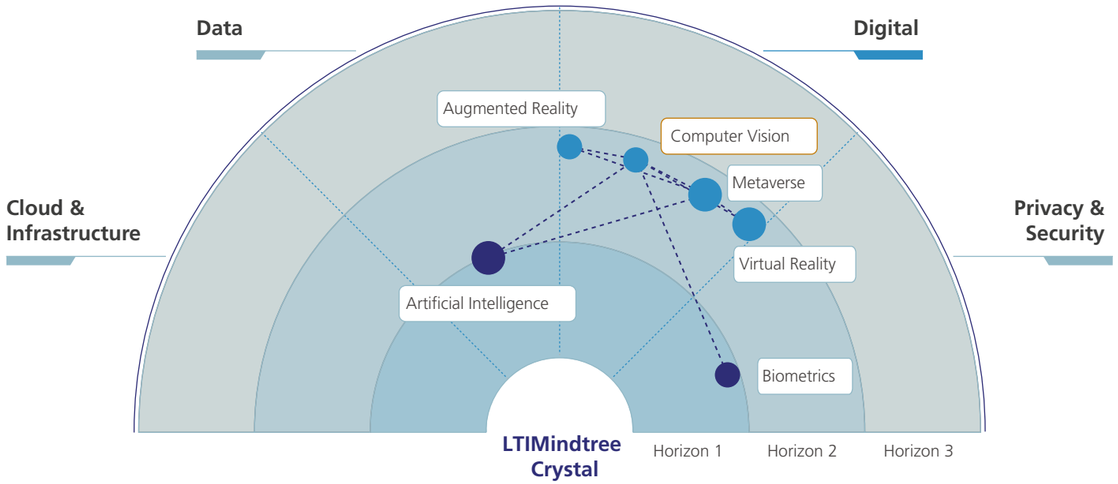
Southeast Asia's first full-spectrum digital bank using a responsive composable banking platform to power **its customer relationship management (CRM) systems**. In addition, it will equip **AI driven solutions** with bank's relationship managers for timely insights to quickly authorize transactions, resolve issues, and delight customers; as a result, customers will experience a concierge-like, smooth, fast, and secure onboarding process.

Computer Vision – **Technology Landscape(1/2)**

Technology Rating

Horizon	Market Potential (USD)	Adoption Phase
Horizon 1	0-100Mn	Emerging
Horizon 2	100Mn-500Mn	Improving
Horizon 3	500Mn–1Bn	Mature
	1Bn–10Bn	
	10Bn +	

Radar Positioning & Related Technologies



CRYSTAL **Insights**

Computer Vision is a rapidly expanding research and application field. The research advancements are now more directly and immediately applicable to the commercial world.

AI developers are introducing computer vision solutions that can recognize and classify objects, as well as react to them in real-time.

Overview

Computer Vision is a field of **AI** that enables **computers and systems** to derive meaningful information from **digital images, videos and other visual inputs** and take actions or make recommendations based on that information. If AI enables computers to think, computer vision enables them to see, observe and understand. Computer vision tasks include methods for acquiring, processing, analyzing, and understanding digital images, and extraction of high-dimensional data from the real world in order to produce numerical or symbolic information.

Computer Vision – **Technology Landscape**(2/2)

How is it a game changer?

Computer Vision, at the forefront of visual innovation, employs **AI** to interpret images and videos, generating actions or recommendations based on what is happening at the time.

According to an **Economist Intelligence Unit** survey **75% of manufacturing companies** claim that the use of computer vision has improved production efficiency and quality control. In addition, computer vision innovations increased cost-cutting efforts across all industries by **10%.**

Computer vision is a rapidly expanding research and application field. **Retail, manufacturing, sports,** and automotive sectors are experimenting with the use of the computer to engage **in-store shoppers, improve quality control** in factories, and improve the **safety of connected cars.**

The technology has enabled numerous innovations, ranging from self-driving cars to facial unlocking for mobile devices. There is enormous potential for computer vision adoption in the **Banking, Financial Services, and Insurance (BFSI)** industry.

Key Use Cases

Life Sciences

- Analysis of CT scans and MRI
- Automate X-ray image diagnosing
- Identify cancerous cells in images

CPG & Retail

- Intelligent video analytics to detect suspicious activity in store
- Detect and count people entering and leaving the store

Manufacturing

- Identifying macro and micro level defects in the production line
- Automatically detect, verify, convert and translate barcodes

BFS

- Customer facial identification data extraction
- Data extraction from trade documents
- Channel sentiment analysis

Featured Story

A vision AI provider deepens relationship with cloud provider to empower enterprises with production-ready computer vision solutions

A US-based provider of vision AI **expanded its partnership with one of the leading cloud providers**. As an Independent Software Vendor (ISV), the company's AI vision solution is now available for resellers on **the cloud provider's Marketplace**. Businesses can now easily deploy end-to-end vision AI to private clouds to realize the full value of their video and other visual data for accurate, actionable insights across diverse use cases.

Conversational Systems – **Technology Landscape(1/2)**

Technology Rating

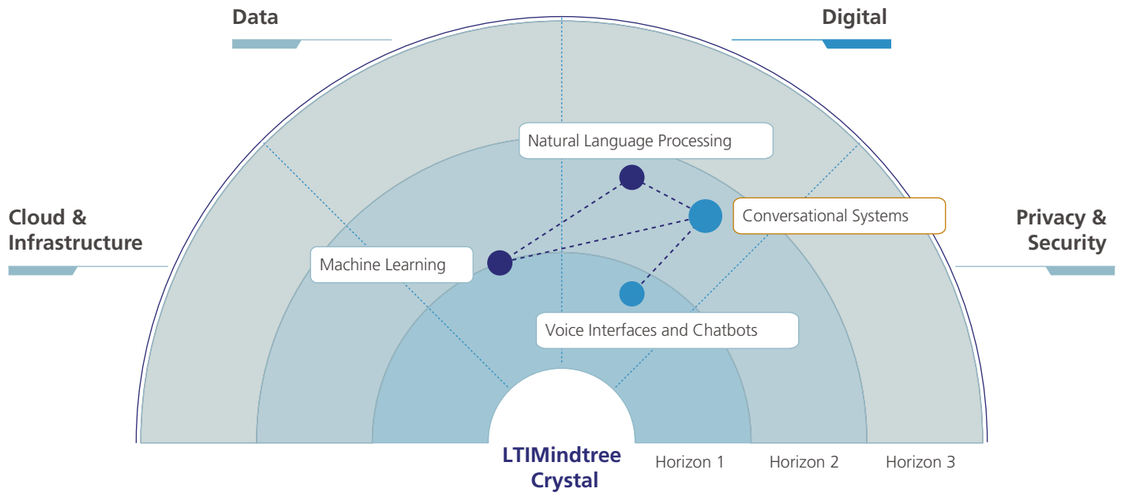
Horizon	Market Potential (USD)	Adoption Phase
Horizon 1	0-100Mn	Emerging
Horizon 2	100Mn-500Mn	Improving
Horizon 3	500Mn–1Bn	Mature
	1Bn–10Bn	
	10Bn +	

CRYSTAL **Insights**

Conversational Systems including chatbots, virtual agents, and voice assistants have become extraordinarily popular over the last few years, with **accelerated adoption post pandemic.**

However, the technology still suffers from several limitations that make it difficult to use and limit its value. The adoption of these solutions will further **increase in the future with advancements in AI technologies** to understand more complex sentences and requests.

Radar Positioning & Related Technologies



Overview

Conversational Systems are intelligent technologies that can engage in **two-way communication** with humans by **deciphering text and speech**. Conversational systems are enabling businesses to automate a significant portion of their **consumer interactions** by handling **text and voice-based** queries in numerous languages. Companies are using conversational systems to drive more engaging consumer interactions and develop more personalized products based on detailed consumer segmentation data. This technology is still limited in that it struggles to interpret the precise emotion and tone of human input.

Conversational Systems – **Technology Landscape**(2/2)

How is it a game changer?

Operating in conjunction with other technologies such as **NLP,** Conversational Systems have the potential to disrupt a variety of sectors by redefining the way businesses interact with their customers. Conversational Systems of the future are likely to be more effective at **self-learning and improving efficacy** over time.

Domain-specific Conversational Systems are likely to be developed to cater to specific industries. Similarly, solutions capable of capturing **potential leads and making personal recommendations** could transform sales processes.

Conversational systems are impacting **banking & finance, healthcare, government, retail, logistics, education, e-commerce, travel, and several other sectors**.

It can be implemented on all major social media platforms including **Facebook, Instagram, WhatsApp, and Twitter.** It has not stopped here; readily available **APIs** are available to integrate into **business systems and CRM**.

Key Use Cases

Life Sciences

- Appointment booking
- Check patients symptoms and recommend courses of action

Retail

- Automate bookings, customer support, etc
- Delivery schedules and inventory management

BFS

- Cross-sell financial products
- Customer engagement and query handling

Real Estate

- Managing multiple conversations simultaneously
- Handling initial conversations
- Lead generation

Featured Story

An AI driven talent engagement platform provider selects a MLOps platform provider for AI chatbot automation

A MLOps platform provider and a provider of AI driven talent engagement for recruiting, announced that the former's MLOps platform has been selected to power a wide range of AI products aimed at increasing the efficiency and scalability of the later's AI operations. The talent engagement company is leveraging automation and AI to speed up the recruitment process, while delivering a hyper-personalized candidate experience. It's AI chatbot engages with candidates across SMS, mobile, and web, matches them to jobs, schedules interviews, and handles intelligent communications, including FAQs. The chatbot pairs conversational AI with automated communication and engagement workflows so organizations can engage with candidates at a scale.

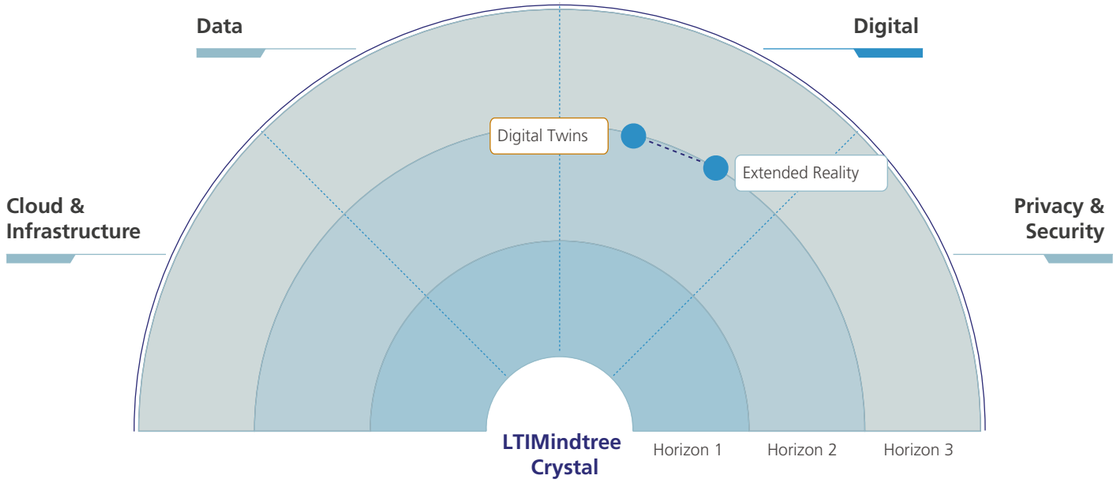
Back to Navigation

Digital Twins – **Technology Landscape**(1/2)

Technology Rating

Horizon	Market Potential (USD)	Adoption Phase
Horizon 1	0-100Mn	Emerging
Horizon 2	100Mn-500Mn	Improving
Horizon 3	500Mn–1Bn	Mature
	1Bn–10Bn	
	10Bn +	

Radar Positioning & Related Technologies



CRYSTAL **Insights**

The adoption of Digital Twins technology is expanding, and digital twins are already in use across many industries, from **healthcare to smart cities.**

Growth in 5G, edge computing and memory processing will improve the interconnectivity of twins which will create new opportunities for this technology.

Overview

A **Digital Twin is a virtual replica** used to run simulations to predict how a process or product may perform in real life. Digital Twins technology also allows users to continually optimize a product or service even after its **physical counterpart has been built.** Digital Twins are reducing operational costs and increasing service efficiency in a variety of industries. **ML and IoT** are the some of the key technologies enabling Digital Twins. A limitation of this technology is that to be truly effective, digital replicas need to be in place throughout the value chain.

Back to Navigation

Digital Twins – **Technology Landscape**(2/2)

How is it a game changer?

Digital Twin technology takes the process of designing a product or service and revolutionizes it by making implementation **iterative and adaptive**, allowing for ongoing optimization. The trends of the Internet of Behavior as well the imminent proliferation of 5G technology will further empower Digital Twins.

This technology's importance lies in its multi-industry applicability. As specialists in this technology grow, expect its adoption across numerous value chains.

Digital Twins can play a key role in helping society to overcome some of its most urgent **sustainability challenges** – like how we make the best use of space, deal with the impacts of climate change and ensure a higher quality of life for all.

Key Use Cases

Manufacturing

Modeling highly complex products processes from plants to determine inefficiencies and address them

Supply Chain & Logistics

Optimize inventory

Plan transportation and facilities

Identify bottlenecks across supply chain

Life Sciences

Patient monitoring without being in proximity

Diagnosis and treatment

Surgery simulation

Government

Smart cities – Urban planning, land-use optimization, energy consumption, waste management, security monitoring and mobility improvements

Featured Story

Ferry company launches digital climate twin ferry project

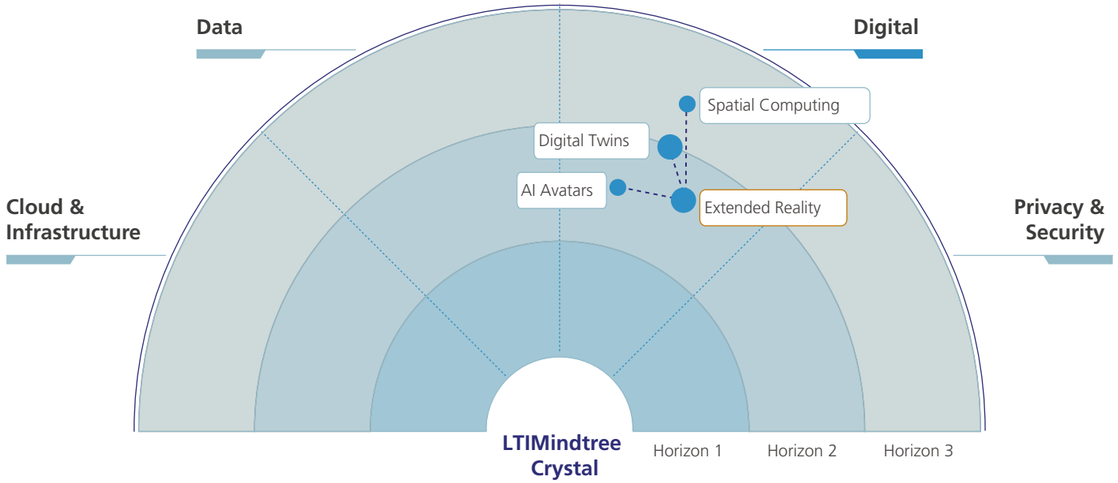
A Denmark-based ferry operator has chosen a European climate tech startup to develop advanced climate twins of its latest **zero-emission ferry design using Life Cycle Assessment (LCA) methodology**. This company will build a detailed life-cycle model representing the vessel from its construction to its end of life many years from now. The model will show the environmental impact of the ferry, not only in its use but also from its construction at **Cemre Shipyard** along with the installed equipment. As explained, the **digital climate twin** will make it possible for the ferry company to run simulations on the use of new green technology on the ferry something that is nearly impossible today.

Extended Reality (XR) – **Technology Landscape**(1/2)

Technology Rating

Horizon	Market Potential (USD)	Adoption Phase
Horizon 1	0-100Mn	Emerging
Horizon 2	100Mn-500Mn	Improving
Horizon 3	500Mn–1Bn	Mature
	1Bn–10Bn	
	10Bn +	

Radar Positioning & Related Technologies



CRYSTAL Insights

Extended Reality is on the path of growth as businesses are looking at it as a tool to enable **workplace transformation.**

Innovative products like **smart glasses** will further attribute to the growth of this technology.

Overview

Extended Reality collectively refers to all immersive technologies, including **VR, AR, and Mixed Reality (MR)**. It can also be powered by computer vision in some cases. XR offers businesses a powerful value proposition by enabling them to showcase products in new, interactive ways. This helps to reduce costs such as floor space and transport, while improving productivity, revenue, and customer satisfaction. The primary barrier to the widespread adoption of **XR is that the initial implementation costs can be high.**

Extended Reality (XR) – **Technology Landscape**(2/2)

How is it a game changer?

XR platforms can help drive immersive, personalized purchase experiences, which helps to increase conversion rates and reduce return rates. AR-capable smartphones, integration with **AI, and the development of 5G are enhancing XR and the virtual experiences associated** with it. XR is also likely to bring about revolutionary changes in telehealth, virtual conferencing, product design, e-commerce, and the entertainment industry.

Mixed Reality in its various forms including AR and VR was an answer to achieving some level of togetherness at work.

People began using XR for everything from collaborative design sessions to meetings to informal hangouts. XR paves our way to access the all-purpose virtual space – Metaverse.

Meta reportedly has **10,000 people working on Mixed Reality**. Apple has more than 2,000 people developing XR. **Google** is developing a **Mixed Reality OS. Startups** such as **Avegant and Lumus** are developing advanced in-lens displays.

Key Use Cases

Gaming

- Natural UI
- Haptic feedback
- First-person perspective
- 6 degrees of freedom
- Avatar game mechanics

Retail

- Virtual try-ons
- Point and find product reviews

Life Sciences

- Allowing patient to view surgical plan to see how things are set to play out
- COVID-19 emergency response

Manufacturing

- Design life size plans to test new production lines
- Remote assistance
- Industrial maintenance

Featured Story

Dubai government launches Metaverse tech strategy

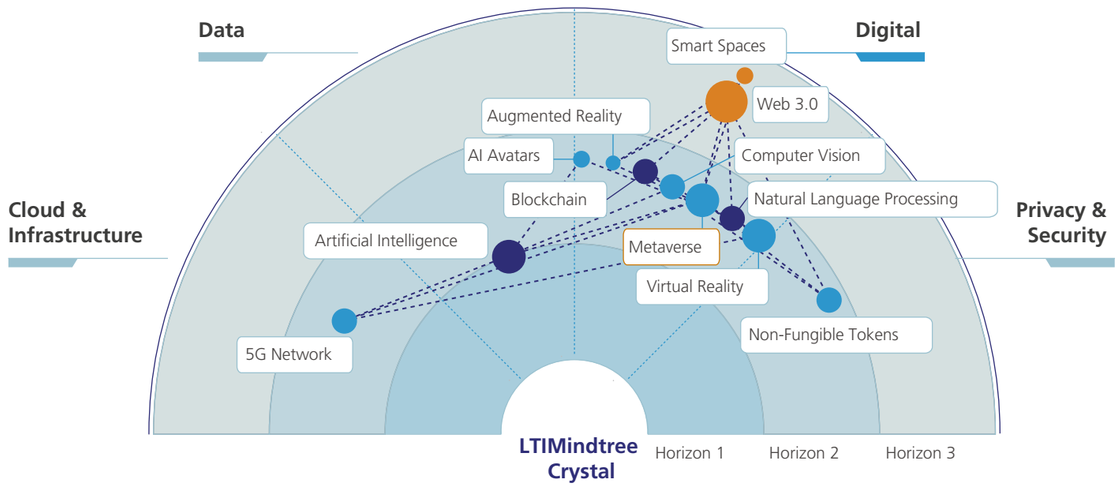
The **UAE's most populous city, Dubai, launched** a major **metaverse strategy** in a bid to become one of the top **10 XR economies worldwide**. Dubai aims to remain a significant technology hub for the Metaverse and developing digital solutions for the country's digital transformation. Dubai's Metaverse strategy is to support **40,000 virtual jobs and add USD 4 billion** to Dubai's economy in 5 years. Dubai has been making massive progress in its global metaverse ambitions, it has invested heavily in capacity development and talent creation, as well as adopting emerging technologies to position Dubai as a central hub for the spatial communications platform, among others.

Metaverse – **Technology Landscape**(1/2)

Technology Rating

Horizon	Market Potential (USD)	Adoption Phase
Horizon 1	0-100Mn	Emerging
Horizon 2	100Mn-500Mn	Improving
Horizon 3	500Mn–1Bn	Mature
	1Bn–10Bn	
	10Bn +	

Radar Positioning & Related Technologies



CRYSTAL **Insights**

Metaverse is at an **improving stage.** It will take time for it to become fully immersive and more refined in order to support the day-to-day activities of people.

Development in AR, VR and brain-computer interface will shape metaverse in the future and help identify real-life use cases.

Overview

A **Metaverse is a network of 3D virtual worlds** focused on social connection. In futurism and science fiction, it is often described as a universal virtual world that is facilitated by the use of virtual and augmented reality headsets. The metaverse is a digital reality that combines aspects of social media, **online gaming, AR, VR, and cryptocurrencies** to allow users to interact virtually. AR overlays visual elements, sound, and other sensory input onto real-world settings to enhance the user experience, **VR enhances fictional realities.**

Metaverse – **Technology Landscape**(2/2)

How is it a game changer?

Leveraging non-fungible **development, robotics, IoT, AR/VR, and blockchain, Metaverse** aims to seamlessly link **virtual and physical worlds to open opportunities** otherwise impossible to experience.

The top sectors that leveraged Metaverse in 2021 are **gaming, entertainment, and retail,** with the brands creating their exclusive collection of virtual items and immersive experiences for their customers.

Metaverse will enable creating personalized experiences across industries and domains, eliminating the physical and digital space lag.

Metaverse will be the perfect shared, multidimensional digital space where worlds and brands collide to create a magical immersive experience.

An exciting opportunity in the Metaverse is that it will essentially be an extension of the internet, encompassing a full-fledged **decentralized economy.**

Key Use Cases

Media & Entertainment

- Immersive storytelling
- Metaverse theme parks

Life Sciences

- AR-based remote expert advisory
- Digital therapeutics

BFS

- Virtual bank branches
- Payments in Metaverse

Retail

- Virtual try-on rooms
- Digital Twin-based model demonstration

Featured Story

Hong Kong University launched world's first Metaverse campus

The Hong Kong University of Science and Technology (HKUST) launched its first **VR campus**. Aiming for building a **MetaHKUST**, Hong Kong's university embraces immersive learning in Metaverse classrooms. HKUST shall debut its **Guangzhou campus** shortly with virtual hosting in a **Mixed Reality setting**. The launch of HKUST's Virtual Reality class is the stepping stone toward building MetaHKUST. The MetaHKUST is being built with the objective of connecting the two campuses for a shared learning environment without limitations.

Natural Language Processing – **Technology Landscape(1/2)**

Technology Rating

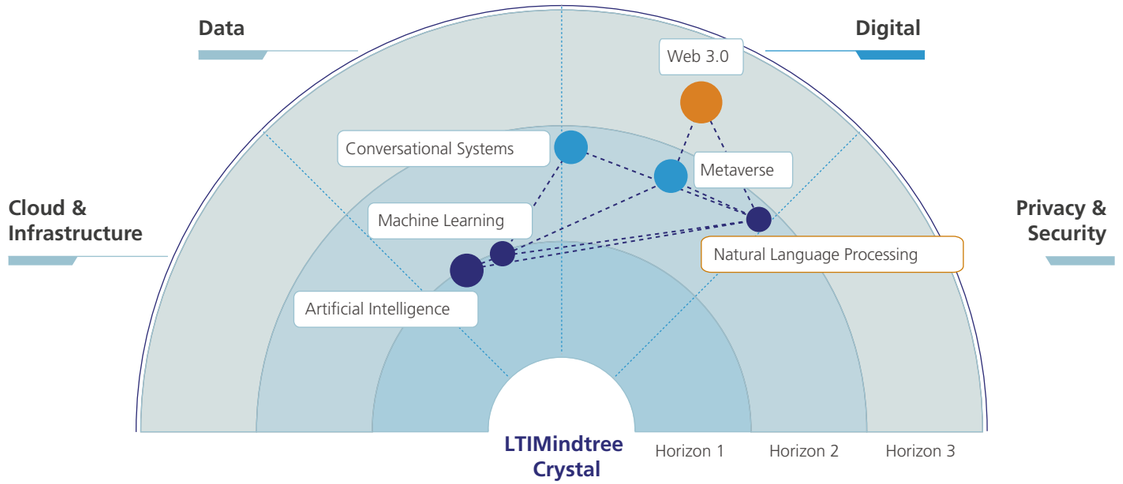
Horizon	Market Potential (USD)	Adoption Phase
Horizon 1	0-100Mn	Emerging
Horizon 2	100Mn-500Mn	Improving
Horizon 3	500Mn–1Bn	Mature
	1Bn–10Bn	
	10Bn +	

CRYSTAL **Insights**

Sectors like **BFS, Media & Entertainment, and Healthcare** are likely to drive **NLP adoption** in the coming years.

Strong NLP foundation is crucial as enterprises look to augment their human workforces with AI-powered systems.

Radar Positioning & Related Technologies



Overview

Natural Language Processing (NLP) is a subset of **AI that uses computational techniques** and algorithms to **read, analyze, and extract complex information** from human language inputs. This technology processes masses of unstructured data to derive meaning and can be used to conduct sentiment analysis. NLP relies on advances in the field of **ML, such as deep learning algorithms**. NLP applications include granular consumer sentiment analysis, seamless chatbot interactions, and nuanced text translation.

Natural Language Processing – **Technology Landscape**(2/2)

How is it a game changer?

This technology could transform **healthcare** by **diagnosing and even predicting illnesses using data from electronic medical records.**

With virtual assistants, NLP can serve as a cognitive aid by learning about users, creating a knowledge repository from text & voice recordings, and organizing unstructured data.

It is critical in the fight against fake news, using deep learning algorithms to detect biased and unverified media. In the legal profession, NLP tools could help lawyers analyze and gain deeper insights from large quantities of legal documents.

NLP has accelerated the shift away from mere keyword searches to using **AI** to conduct comprehensive analyses, deriving rich insights from unstructured data.

It has already begun disrupting the retail industry by transforming how businesses interact with their customers via technologies like **chatbots and voice analysis.**

Key Use Cases

Media & Entertainment

- Contextual content search engines
- Sentiment analysis

Life Sciences

- Clinical documentation using Part-of-Speech (PoS) tagging

BFS

- Data cleaning and preprocessing
- Classifying financial statement

Technology

- Automated replies
- Predictive texts

Featured Story

US-based healthcare provider to use AI, NLP to improve revenue cycle management

US-based healthcare provider signed a ten-year agreement with an **AI company** to improve its **revenue cycle management processes** through **Natural Language Processing**. The healthcare provider will leverage **AI** to automate its revenue cycle activities and speed up document processing, including initial chart reviews. Through the deal, the healthcare provider aims to improve its revenue cycle management accuracy and, in turn, ensure that it continues to meet patient needs. The provider employs over **16,000 physicians** and offers more than 100 medical specialties to two million people across New York every year. Also, it has **22 hospitals** and more than **800 outpatient** facilities in its network.

Quantum Communication – **Technology Landscape(1/2)**

Technology Rating

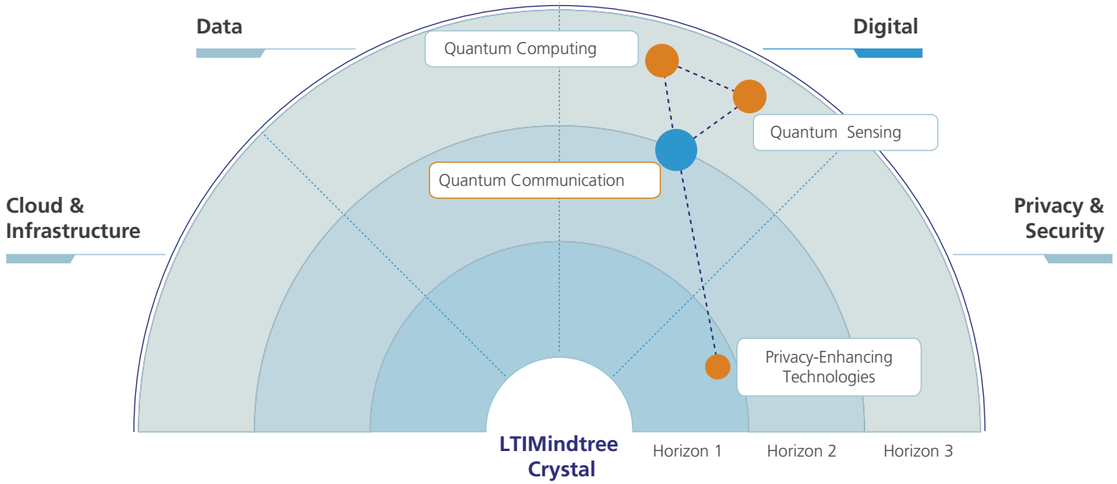
Horizon	Market Potential (USD)	Adoption Phase
Horizon 1	0-100Mn	Emerging
Horizon 2	100Mn-500Mn	Improving
Horizon 3	500Mn–1Bn	Mature
	1Bn–10Bn	
	10Bn +	

CRYSTAL **Insights**

In 2021, investments in Quantum Communication increased to nearly **USD 2.2 billion.**

The adoption of Quantum Communication will vary due to maturity levels and consumer interest.

Radar Positioning & Related Technologies



Overview

Quantum Communication refers to the **transmission** of **data** between two or more endpoints using **individual** or **entangled** particles. **Qubits** are used to transmit and control information using laws of **quantum mechanics.** Quantum Communication requires the concept of quantum theory to secure information transfer. Using the unique principles of quantum physics, Quantum Communication uses encryption to
safeguard data.

Quantum Communication – **Technology Landscape**(2/2)

How is it a game changer?

Twin-track advances in cryogenic cooling and optical table design are presenting opportunities for fundamental scientific breakthroughs in quantum communications, allowing researchers to optimize the performance of secure, long-distance **Quantum Key Distribution (QKD)** using engineered single-photon-emitting light sources.

Methods for enabling secure communication are provided by quantum communication.

In contrast to traditional cryptography, **QKD** enables verifiably secure communication between distant parties without relying on computational complexity assumptions.

With the right hardware, QKD over distances can create a bridge. Quantum Communication has the largest estimated market after quantum computing. As per McKinsey (2021), there are currently **~111 active players** in the field of Quantum Communication.

Key Use Cases

Government

Protecting classified and sensitive data in government and defense industry

Technology

Quantum keys for enhanced device security at personal and professional front

Life Sciences

Protecting sensitive data in RDCS (Registered Diagnostic Cardiac Sonographer)

BFS

Protecting sensitive client information and safeguarding critical business data in banking and financial services industries

Featured Story

A Japanese multinational announces breakthrough in long distance Quantum Communication

A research lab in Cambridge and a **Japanese multinational corporation** have successfully demonstrated QKD on fibers of record 600km length. This has the potential to resolve one of the most difficult technological challenges in building the quantum Internet, of how to transmit quantum bits over long optical fibers. This new dual-band stabilization technique cancels the problem of temperature and strain fluctuations to allow long-distance quantum communication.

Smart Technology – **Technology Landscape(1/2)**

Technology Rating

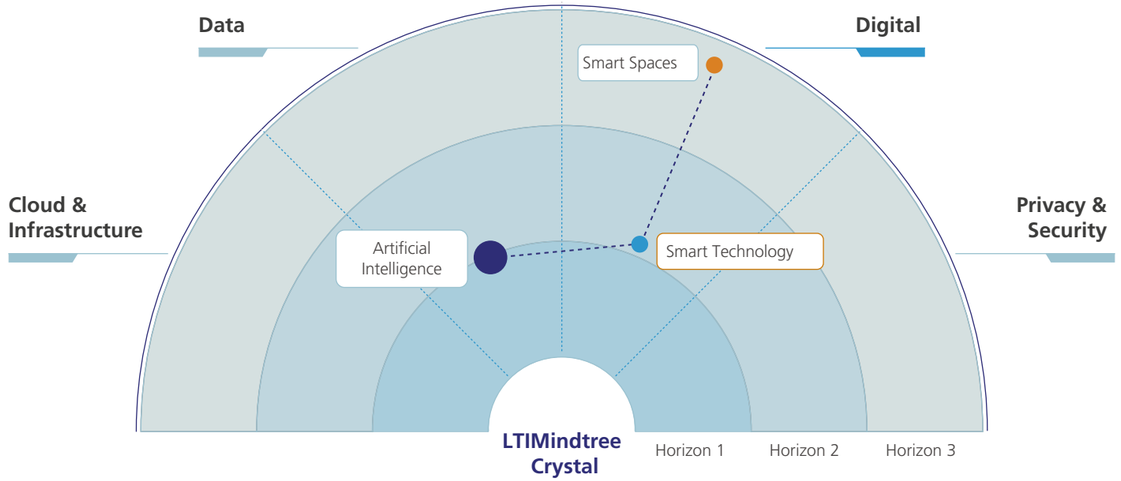
Horizon	Market Potential (USD)	Adoption Phase
Horizon 1	0-100Mn	Emerging
Horizon 2	100Mn-500Mn	Improving
Horizon 3	500Mn–1Bn	Mature
	1Bn–10Bn	
	10Bn +	

CRYSTAL **Insights**

Businesses across the world are increasingly deploying **Smart Technologies** in order to achieve their **productivity, sustainability**, and other objectives.

Technologies like **AI, ML, Deep Learning** are finding applications in multiple industries to develop **intelligent networks throughout the value chain and improve performance.**

Radar Positioning & Related Technologies



Overview

Smart Technology relies on **smart devices** that are equipped with one or several sensors that provide data that they use to analyze and infer from, drawing conclusions from preprogrammed rules, confer with other smart devices, and act accordingly. To do that, they also need a certain amount of computing power, one or more actuators, and communication capabilities (such as Bluetooth or Wi-Fi). Smart machines that use artificial intelligence or automation are on the rise, even in small-scale units and smaller implementations.

Smart Technology – **Technology Landscape(2/2)**

How is it a game changer?

In an obvious way, **Smart Technology** continues to transform daily lives. Smart cities are being built on digital technology and device connectivity that enhances quality of life for the population. From a parking meter to a bicycle helmet, to a trash can or smart vehicle, anything can be turned into a smart device. **Amsterdam is one such smart city.**

Filtering air is only one step toward creating a more livable environment; if pollutants are allowed to accumulate in the future, all the hard work will be undone. Because **solid waste incineration and landfill** generate gases that degrade air quality, addressing dirty streets is critical to preserving urban air quality. Smart technology is assisting in ensuring **on-time waste disposal.**

The healthcare industry accumulates a vast amount of data on a day-to-day basis; medical histories, images of ultrasounds, pharmaceutical and therapy research data to name a few sources. Smart tech solutions can sift through that data, connect the dots between relatable data and give practitioners a greatly reduced summary of relevant case information in as little as 30 seconds.

Key Use Cases

Manufacturing

- Smart factory
- Smart logistics

Government

- Smart grid management
- Control pollution and temperature using smart technologies

BFS

- IoT applications in ATMs
- Automate sales processes or customer service inquiries

Featured Story

A British university looks at smart technology to safeguard drinking water

The **UBCO university engineers are teaming up with a telecom company** and the regional district to investigate how **smart technology** can help **monitor drinking water quality**. The new collaboration integrates **wireless monitoring to manage water quality**. This new smart monitoring solution aims to improve how municipalities monitor water and its quality at the tap for thousands of residents across the region.

Virtual Reality (VR) – **Technology Landscape(1/2)**

Technology Rating

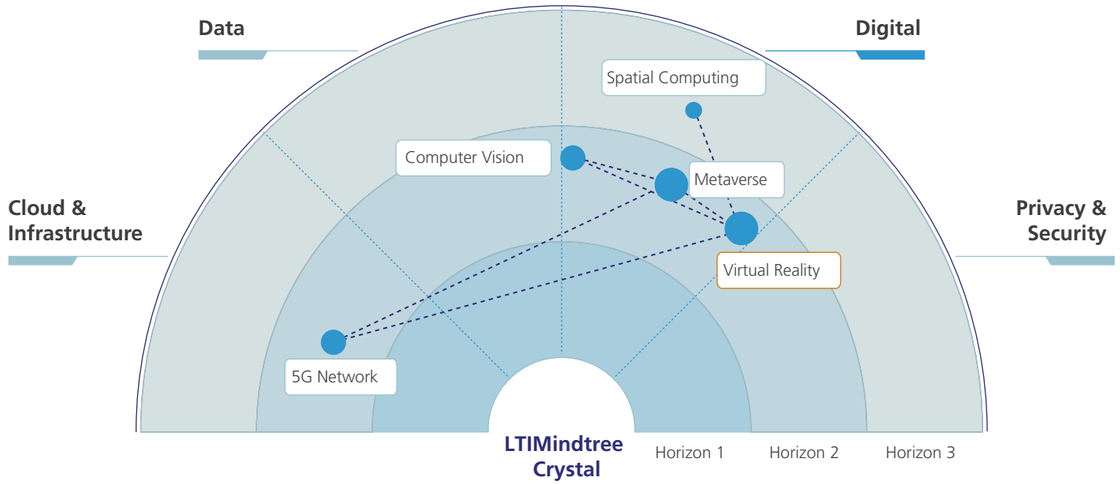
Horizon	Market Potential (USD)	Adoption Phase
Horizon 1	0-100Mn	Emerging
Horizon 2	100Mn-500Mn	Improving
Horizon 3	500Mn–1Bn	Mature
	1Bn–10Bn	
	10Bn +	

CRYSTAL **Insights**

Virtual Reality has been gradually growing in popularity across all industries with expected consumer spending accounting to **60% and enterprise spending accounting to 40%** of the total VR market in 2025.

VR has the potential to drive the future of a wide range of industries including manufacturing, journalism, and healthcare, among others.

Crystal Positioning & Related Technologies



Overview

VR, is the use of **computer modeling** and **simulation** that enables a person to interact with an artificial three-dimensional (3-D) visual or another sensory environment. VR has made it possible for everyday people to exist in multiple different realities. Recognizing the growth potential, investors have accelerated their interest in the AR/VR industry, even amid a global pandemic and subsequent economic uncertainty.

Virtual Reality (VR) – **Technology Landscape**(2/2)

How is it a game changer?

Virtual Reality is one of the technologies with the highest projected potential for growth.

Virtual reality devices and technologies can be used to **supervise** the **workflow in a factory**, ensuring timely activities and production.

The Virtual Reality technologies can also be used by the supervisor in order to ensure the safety of the workers by knowing their location as well as getting warnings for dangerous zones.

VR meeting environments might come with instant **access to 3D documents and content** that team members can interact with during a conversation. They can include virtual avatars that look like the people joining a meeting, so everyone can sit in a digital room together.

The **Spanish National Research Council** has succeeded in reducing the effects of Parkinson's in several patients by applying a treatment that uses VR.

Key Use Cases

Media & Entertainment

VR for sports in 360 –degree format

VR in live concerts with simulations of 3D images of artists and surroundings

Automotive

Helps car manufacturers in analyzing road scenarios and the behavior of cars

Life Sciences

Locate veins in patients while being injected

Treatment for mental health issues, with VR exposure therapy

Architecture

Architects can envision what they are building as well as feel it

Featured Story

Tequesta police use Virtual Reality to train officers

The Tequesta department is using **VR** to put officers in hundreds of different dangerous scenarios in the hopes that if they ever are in those situations in real life, they will have the skills to be successful and hopefully save lives. To use the system, officers put on a **Virtual Reality headset** and are transported into a **hostage situation, an active shooter scenario, or responding to a person in mental distress.**

Cybersecurity Mesh – **Technology Landscape(1/2)**

Technology Rating

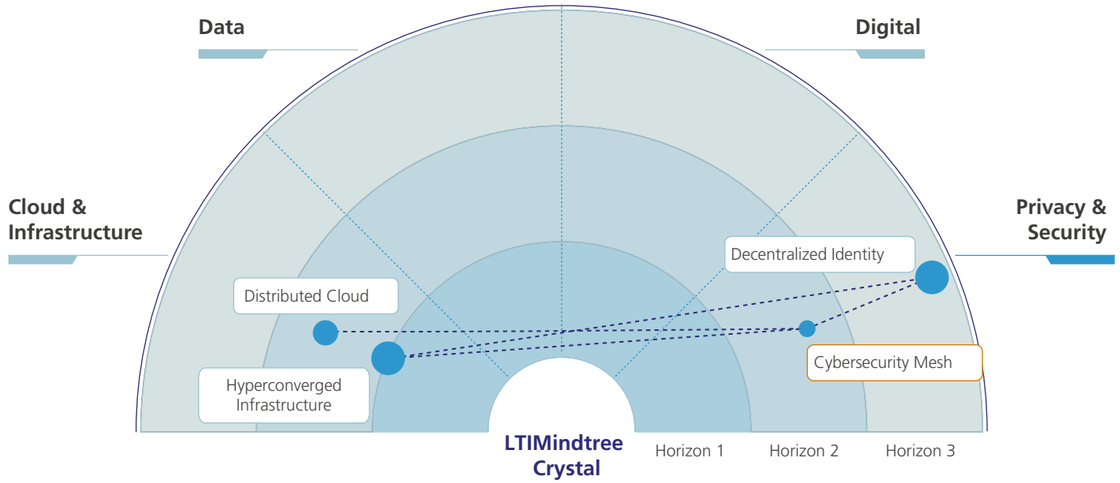
Horizon	Market Potential (USD)	Adoption Phase
Horizon 1	0-100Mn	Emerging
Horizon 2	100Mn-500Mn	Improving
Horizon 3	500Mn–1Bn	Mature
	1Bn–10Bn	
	10Bn+	

CRYSTAL **Insights**

Cybersecurity Mesh is the most practical and adaptable approach to address security challenges beyond pre-defined perimeters.

This technology is driven by **advanced threat intelligence** and evolves further with the emergence of new threats.

Crystal Positioning & Related Technologies



Overview

Traditional **fragmented security approaches** focused on enterprise perimeters leave organizations open to breaches. **A cybersecurity mesh architecture** provides a composable approach to **security based on identity** to create a scalable and interoperable service. The common integrated structure secures **all assets, regardless of location**, to enable a security approach that extends across the foundation of IT services. Cybersecurity mesh is a building block of a **Zero Trust security strategy** where devices, services, data, and applications are accessed securely from anywhere by humans or machines with strict identity verification and authorization.

Cybersecurity Mesh – **Technology Landscape**(2/2)

How is it a game changer?

After the **COVID-19 pandemic**, several organizations have **introduced remote working business models** to meet mandatory regulations and now looking forward to continuing with this new way of working or opting for a **hybrid model** as it reduces their operating expenses.

In addition, enterprises are **moving** their **assets and critical data** from **on-premise infrastructure to the cloud.** All these scenarios now changed the way how employees access the assets of the company.

As the employees are accessing assets outside of pre-defined security perimeters, enterprises must rethink their **cybersecurity strategies.**

Cybersecurity mesh is focused on securing digital assets located anywhere and it allows enterprises to address threats. Thus, it is gaining interest in **banks, healthcare, IT and manufacturing sectors** to protect **individual and third-party access points.**

Gartner stated that organizations who **adopt cybersecurity mesh** will reduce the financial impact of individual security incidents by an average of **90% by 2023.**

Key Use Cases

Technology

- Redefine security perimeters around the identity of employees
- Privacy in online interactions

BFS

- Identity and access management of staff and customers
- Distributed security based on asset locations

CPG & Retail

- Identity and access management of online customers

Life Sciences

- Identity and access management of patients

Featured Story

Telecom service provider partners with cybersecurity company for customer security

A Trinidad and Tobago's national telecommunications provider collaborated with a **US-based multinational cybersecurity company**, to integrate **network security solutions into its business suite of networking services and security frameworks**. This networking solution continuously assesses network risks and automatically adjusts to provide comprehensive real-time protection across the digital attack surface and cycle. This network security solution is the industry's highest-performing integrated **cybersecurity mesh platform** with the broadest open ecosystem.

Deception Technology – **Technology Landscape(1/2)**

Technology Rating

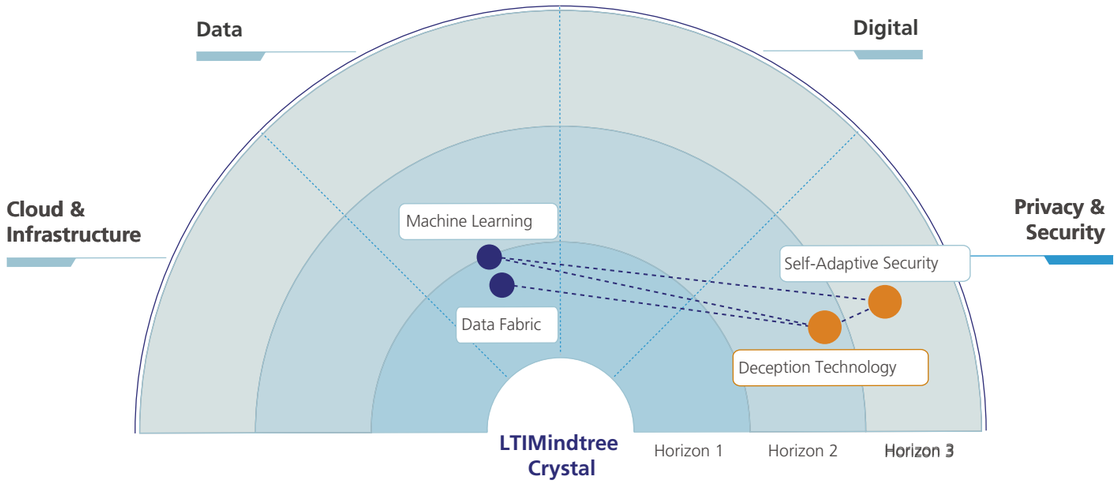
Horizon	Market Potential (USD)	Adoption Phase
Horizon 1	0-100Mn	Emerging
Horizon 2	100Mn-500Mn	Improving
Horizon 3	500Mn–1Bn	Mature
	1Bn–10Bn	
	10Bn +	

CRYSTAL **Insights**

Deception Technology is a new cyber defense method, different from other technologies that try to identify attackers such as honeypots and sandboxing.

Gartner has predicted that by 2022, **25% of all threat detection and response** projects will include deception features and functionality.

Radar Positioning & Related Technologies



Overview

Deception Technology refers to a set of tools designed to **deceive hackers and prevent** them from doing significant damage once they have infiltrated a network. Deception Technologies **improve on traditional "honeypots"** in that they are more dynamic and act as more intelligent alert systems. This technology will be critical to protecting customer information from threats and vulnerabilities, particularly in the **banking, finance, and healthcare sectors**. Deception Technology may become a cornerstone of **legislation governing** the ways businesses safeguard consumers' data privacy rights.

Deception Technology – **Technology Landscape**(2/2)

How is it a game changer?

Deception Technology has the potential as a means of developing **intelligent countermeasures** for a variety of cyberattacks in multiple industries.

This technology is related to trends such as **data ownership** that focus on the individual's **data privacy rights** and the best ways to **safeguard the sensitive data** hosted online.

Expect future iterations of this technology to become more efficient in decreasing attacker dwell time while expediting **attack detection and remedy times.**

Deception technology users claim that this technology responds to **deception-based alarms 12 times faster** than other alerts do, which eventually helps them **save 32%,** or about **USD 20,000 per SOC analyst each year.**

These instruments are particularly useful for high-profile targets including **financial institutions, healthcare providers, governmental facilities, and research organizations**. Recent assaults against civilians and key infrastructure demonstrate the need for deception technology.

Key Use Cases

BFS

Defending legacy, custom applications and systems

Guarding the integrity of wire transfer services

Utilities

Deception for attack detection of distribution systems

Early detection of threats and actionable alerts

Manufacturing

Safeguard Information Technology (IT) and Operational Technology (OT) networks

Life Sciences

Meet HIPAA and HITECH patient data protection mandates

Protecting patient data from Insiders and Outsiders

Featured Story

An industrial control systems leader expands OT cybersecurity portfolio with active defense and deception technology solution

An industrial control systems leader and a cyber deception solutions provider, together introduced a new solution designed to detect known and unknown (zero-day) attacks across the operational technology (OT) environments in commercial buildings. The combined solution employs sophisticated active defense featuring autonomous deception tactics to outsmart attackers and provides high fidelity threat detection.

Non-Fungible Tokens – **Technology Landscape(1/2)**

Technology Rating

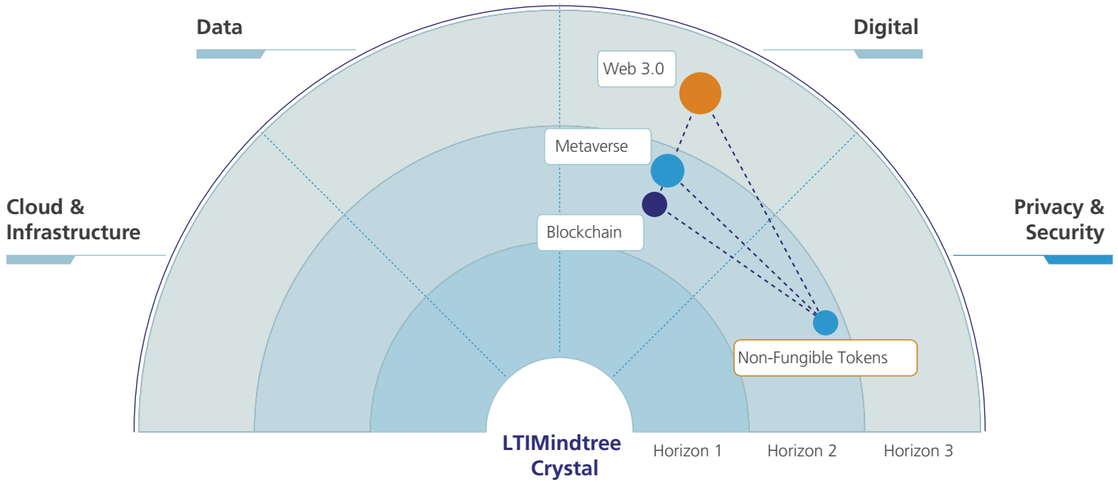
Horizon	Market Potential (USD)	Adoption Phase
Horizon 1	0-100Mn	Emerging
Horizon 2	100Mn-500Mn	Improving
Horizon 3	500Mn–1Bn	Mature
	1Bn–10Bn	
	10Bn +	

CRYSTAL **Insights**

NFTs along with smart contracts have the potential to replace the traditional centralized organizational construct with a more decentralized construct, termed **Decentralized Autonomous Organization.**

NFT is steadily shifting to the mainstream with **increasing investments from angel investors and major organizations globally.**

Radar Positioning & Related Technologies



Overview

Non-Fungible Tokens (NFTs) are cryptographic assets on a **blockchain** with **unique identification codes and metadata** that distinguish them from each other. **Unlike cryptocurrencies,** they cannot be traded or exchanged at equivalency. This differs from fungible tokens like cryptocurrencies, which are identical to each other and, therefore, can serve as a medium for commercial transactions. In practice, NFTs can be any sort of digital item that someone might want to own, such as a piece of music or a painting or like unique collectible card.

Non-Fungible Tokens – **Technology Landscape**(2/2)

How is it a game changer?

The maximum capacity of **NFTs** has yet to be reached. It will be fascinating to observe how it'll benefit the creator economy, now that internet will be largely decentralized with NFT as the basic enabler.

NFTs aided in the identification and value of many **digital asset owners, and the blockchain's smart contract characteristics** will be integrated into asset appraisals in the future.

Since the beginning of **2021**, the market capitalization of **NFT has grown from USD 23 million to USD 432 million**. Interestingly, the scope of NFT isn't limited to arts anymore. It has extended to music, videos, games, sports, fantasy sports, real estate, domain names, and much more.

NFT is a digital asset that is cryptographically saved on a blockchain, which is a distributed database that facilitates secure and verified transactions between two or more parties.

Key Use Cases

Media & Entertainment

- Play-to-Earn games
- Cross-platform tradable assets

E-commerce

- NFTs to store entire product journey – from manufacturing to shipment

BFS

- Loyalty points or reward tokens
- Secure – transparent transactions

Technology

- Digital ownership of physical assets
- Digital identity verification

Featured Story

A sports NFT marketplace selected at I-Tech Cup game between Tottenham Hotspur F.C. & A.S. Roma

A US-based web3 company announced its social-plus sports NFT marketplace was selected by **Sports Tech Startup** as a technology solution at the **I-Tech Cup match between Tottenham Hotspur F.C. and A.S. Roma**. As a part of their solution, the web3 company will issue **commemorative NFTs** via their **web application**. These serve as a memory of the iconic match but also double up as instruments for randomized rewards in form of other NFTs and **sports memorabilia**. Commemorative NFTs are in some ways similar to ticket stubs that a fan may keep as a memory of them attending their team's match - just that it's a digital and permanent record.

Horizon **3**

Advanced Swarm Systems – **Technology Landscape(1/2)**

Technology Rating

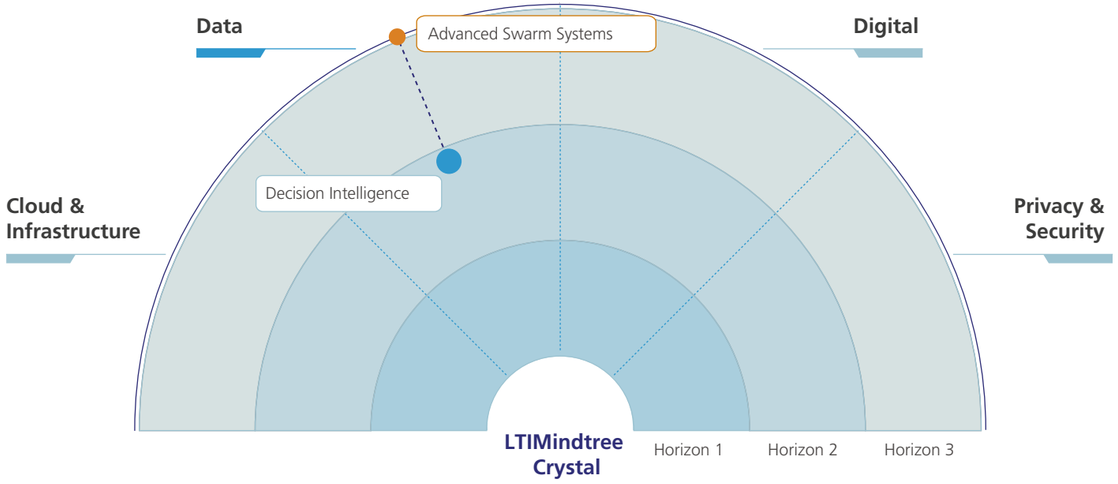
Horizon	Market Potential (USD)	Adoption Phase
Horizon 1	0-100Mn	Emerging
Horizon 2	100Mn-500Mn	Improving
Horizon 3	500Mn–1Bn	Mature
	1Bn–10Bn	
	10Bn +	

CRYSTAL **Insights**

Increasing investments in advanced swarm systems is attributed to the growing procurement of UAVs by the defense sector.

Advanced Swarm Systems is in the **nascent stage** and there is less awareness about the technology. However, there is rising adoption in the military & transportation sectors.

Crystal Positioning & Related Technologies



Overview

Advanced Swarm Systems arise from **swarm intelligence**, which refers to the collective intelligence of a group of **self-organized, decentralized systems**. Swarm systems are used in fields ranging from troubleshooting manufacturing errors and designing precision drug delivery systems to deploying tiny spacecraft for space exploration. Technologies such as **deep learning, cloud computing, robotics, and data analytics** support Advanced Swarm Systems.

Advanced Swarm Systems – **Technology Landscape**(2/2)

How is it a game changer?

Advanced Swarm Systems can solve complex problems with unprecedented accuracy compared to isolated or standalone systems, which use a single source of data to draw inferences.

The technology can replace many AI-based systems where predictions are made related to group behavior. In a dynamic and complex world, swarm intelligence will help businesses identify potential sources of growth amid the chaos and help them prepare for future disruptions.

Currently, each **UAV (Unmanned Aerial Vehicle)** requires its own controller. However, advances in chip technology and **software** are making it possible for simple drones to communicate with one another.

With so many military technologists working on **drone swarms**, they may soon become the most cost-effective way to conduct many types of aerial missions. The hardware is already available, and it may not be long before technologists are able to enable many individual drones to function as a cohesive, integrated unit.

Key Use Cases

Manufacturing

Used for detecting chemical leaks & industrial pollution

Self monitoring and blocking the source

Government

Leveraging UAVs acting together as swarm

Autonomous action while searching for targets

Industry Emergency Management

Robot swarm to locate avalanche victims

Oil & Gas

Fleet of low-cost oil-absorbing robots called Seaswarm for ocean-skimming and oil removal

Featured Story

OFFSET awards contract to advance swarm tactics for urban missions, enhance physical testbeds

Defense Advanced Research Projects Agency (DARPA) has awarded contracts to nine performers to begin work on the agency's **OFFensive Swarm-Enabled Tactics (OFFSET) program's fifth swarm sprint**. The program envisions swarms of up to 250 collaborative autonomous systems providing intelligence to ground troops operating in dense urban areas. OFFSET has five key thrust areas – swarm tactics, swarm autonomy, human-swarm teaming, virtual environment, and physical testbed with its each sprint emphasizing one of those areas. The swarm sprints aim to encourage rapid innovation and continuous incorporation of the very latest technologies.

Affective Computing – **Technology Landscape(1/2)**

Technology Rating

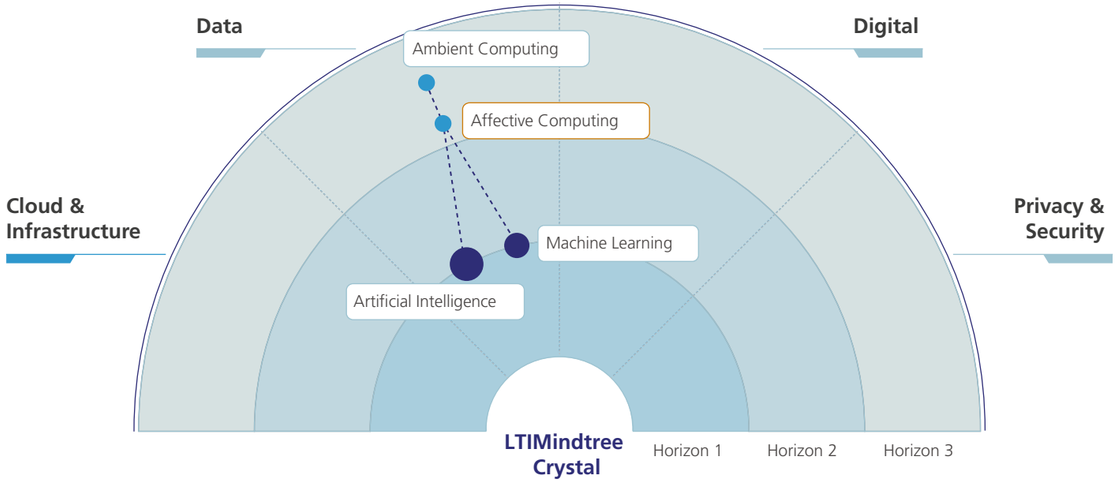
Horizon	Market Potential (USD)	Adoption Phase
Horizon 1	0-100Mn	Emerging
Horizon 2	100Mn-500Mn	Improving
Horizon 3	500Mn–1Bn	Mature
	1Bn–10Bn	
	10Bn +	

CRYSTAL **Insights**

Affective Computing is an **improving technology** that has entered various domains; from **healthcare, retail, to marketing and customer service.**

Multiple Governments are putting efforts to **ethically use affective computing technology** are encouraging the adoption of the technology.

Radar Positioning & Related Technologies



Overview

Affective Computing also called **Emotional AI** is a technology that allows systems to interpret and respond to **facial expressions, voice patterns, and speech using AI.** Combining the fields of computer science, psychology, and cognitive science, this technology will redefine how computers interact with humans, disrupting several industries by deeply personalizing the user experience. The high implementation costs of Affective Computing are one of the critical barriers to mainstream adoption.

Affective Computing – **Technology Landscape**(2/2)

How is it a game changer?

Affective Computing is experiencing a wave of new and expanded use cases and AI vendors are developing innovative capabilities to help businesses monetize this opportunity.

This technology's eventual adoption will disrupt multiple industries and have a tangible impact on associated technologies such as conversational systems. At the **psycho-social level, emotionally-intelligent AI** will also assist humans in better understanding their own mental health patterns and redefine the role technology plays in human wellbeing.

With the advancement of affective computing technology, researchers can objectively identify and measure a learner's affective status in **real-time** throughout the entire learning process, and they can then understand the interrelationship between **emotion, motivation, and learning performance.**

Key Use Cases

CPG & Retail

Monitoring customer's satisfaction level during shopping experience

Insurance

Insurance companies to use voice analysis to determine if a customer is lying when filing a complain

Technology

Affective computing can be integrated into IoT and other smart devices

Life Sciences

Adequate counselling sessions to track and understand mental states of patients

Featured Story

Emotion recognition AI technology adopted by a Japanese automobile leader

An in-cabin sensing AI startup installed cameras in cars to detect and respond to the behavior and emotions of drivers and passengers. Emotional technology monitors drivers' drowsiness. It can be used to trigger alerts, postures & positioning, link to smart seats to improve passenger comfort, and avoid road rage and impatient accidents.

Ambient Computing – **Technology Landscape(1/2)**

Technology Rating

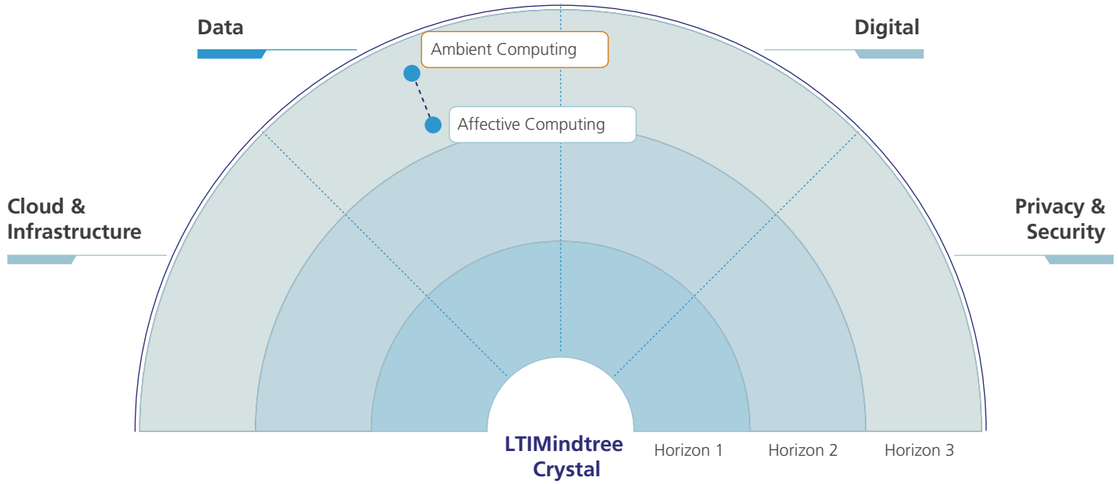
Horizon	Market Potential (USD)	Adoption Phase
Horizon 1	0-100Mn	Emerging
Horizon 2	100Mn-500Mn	Improving
Horizon 3	500Mn–1Bn	Mature
	1Bn–10Bn	
	10Bn +	

CRYSTAL **Insights**

Ambient Computing will play a **crucial role in branding and marketing** as it will allow brands to place their products in an interactive environment using voice-enabled AR glasses.

In addition, its adoption will grow with rising demand for **smart technology and growing private-sector investments in Anti-Money Laundering (AML) technology.**

Radar Positioning & Related Technologies



Overview

Ambient Computing is a broad term that describes an environment of **smart devices, data, AI decisions, and human activity** that enables computer actions alongside everyday life, without the need for direct human commands or intervention. The combination of **endpoint hardware, software, user experience, and machines/human-machine** interaction and learning is the fabric of everyday life. It is about using a computer or far-field communication-enabled device or internet-enabled device, without necessarily consciously using it.

Ambient Computing – **Technology Landscape**(2/2)

How is it a game changer?

There will probably be even more ambient computing in the future. Numerous **gadgets** can already **detect** when you wake up. **Smart technologies** may one day be able to open your curtains so you may wake up to natural light rather than setting up an alarm.

Moreover, ambient computing is being used by several **hardware** manufacturers in both their **marketing** and **design** philosophies. For instance, the smart home operating system used by Samsung, referred to as "**Project Ambience**" enables guests in Samsung City's Home District to have a conceptual look at the automated living space of the future.

Similarly, **Google** is expected to increase the number of hardware products in its lineup so that they better match its current selection of integrated services.

Key Use Cases

CPG & Retail

Personalized shopping experience in physical stores through the concept of unmanned supermarkets

Life Sciences

Personalized treatment and remote patient care

Manufacturing

Connected intelligent devices across the machinery to monitor the real time data

Logistics

Worker safety, remote trouble-shooting, and preventive measures

Featured Story

The latest concept from a recognized automaker demonstrates the potential of ambient computing

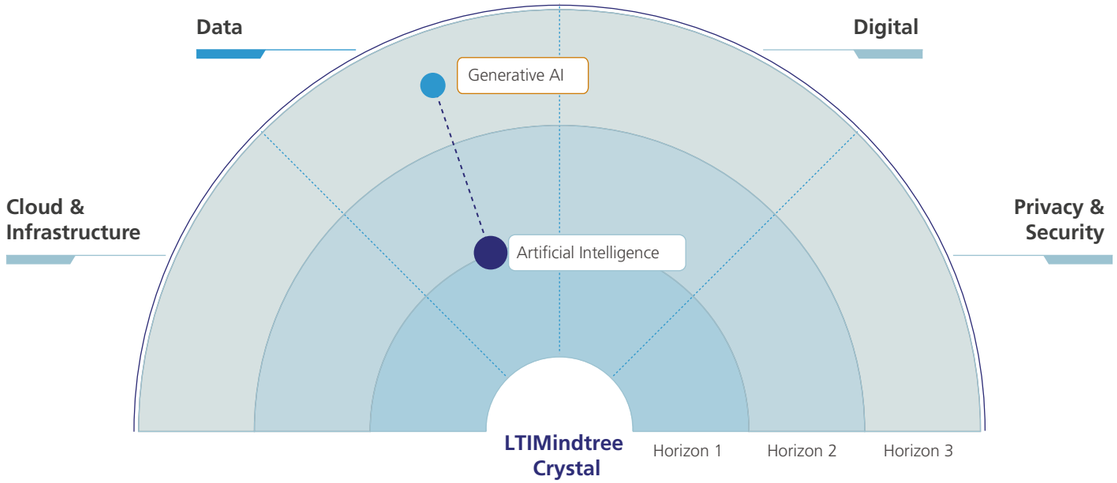
An India-based automaker recently unveiled a new concept, its vision for the future of how EVs should be like. Based on their EV-only Gen 3 platform architecture, the company has moved on from the basics, such as range and performance, and focused on other aspects of how we use cars in general. Wellness was one of the keywords that was sprinkled throughout the presentation, but another important innovation was how the company is looking at the future of car interiors. There are minimal touchscreens and displays in the car, and whatever there are, are meant to display the absolute basics of information. Things that enable this include the increasing role of voice activated commands, as well as the heads up display. What automaker has essentially done is bring ambient computing into the car industry.

Generative AI – **Technology Landscape**(1/2)

Technology Rating

Horizon	Market Potential (USD)	Adoption Phase
Horizon 1	0-100Mn	Emerging
Horizon 2	100Mn-500Mn	Improving
Horizon 3	500Mn–1Bn	Mature
	1Bn–10Bn	
	10Bn +	

Radar Positioning & Related Technologies



CRYSTAL Insights

The field of Generative AI will progress rapidly in **scientific discovery and technology commercialization.**

However, technology providers need to focus on improving safety concerns and negative use, such as **deepfakes**, for its widespread adoption in other areas.

Overview

Generative AI is a type of **AI** that uses **unsupervised learning algorithms to create new digital images, video, audio, text, or code.** For the most part, AI is trained to produce conclusions, but true force-multiplying technologies can innovate on their own. Generative AI is a form of AI that **learns a digital representation of artifacts** from sample data and uses it to generate new, original, realistic artifacts that retain a likeness to the training data but don't repeat it. That allows generative AI to be an engine of rapid innovation for enterprises.

Generative AI – **Technology Landscape**(2/2)

How is it a game changer?

Generative AI is set to penetrate more industries than we can imagine. It is being used in important industries like **entertainment, healthcare, software development, manufacturing, and defense**. According to Gartner, by 2025, Generative AI will account for **10%** of all data produced, up from less than 1% in 2021.

During the **COVID-19 pandemic**, several people moved to **OTT platforms like Netflix, Hot Star, Amazon Prime, etc**. to watch movies and web series and are expected to continue to use these platforms for entertainment. This is also creating the demand for **dubbed foreign films** and series. **Generative Machine learning algorithms and generative AI** will play an important role to create realistic dubbed foreign films. These technologies can train datasets to create new lip movements on the faces of actors to suit the dubbed speech.

It is expected that the **European Union** will pass legislation to mandate the **watermarking** of **AI-generated artifacts by 2024.**

Key Use Cases

BFS

Improve chatbots and voice assistants as they learn how to respond in a more humanistic form

Fraud prevention

Media & Entertainment

Film Restoration - Improve old images and movies by upscaling them to 4K and beyond

Native dubbing to translates video content into various languages

Life Sciences

Monitor the behavior and movement patterns of patients before using generative AI to render the design of the prosthetic limb

Featured Story

Biotechnology company to deploy AI for drug design software

A France-based AI technology provider for new drug design and a **UK-based drug discovery Clinical Research Organization (CRO)** formed an agreement in AI for **new drug design**. Under this agreement, the biotechnology company will **deploy generative design software of** AI technology company, to facilitate the rapid and efficient design of novel compounds and accelerate lead optimization, CRO's drug design expertise and deliver its integrated drug discovery solutions to its global customer base.

3D Memory Chip – **Technology Landscape(1/2)**

Technology Rating

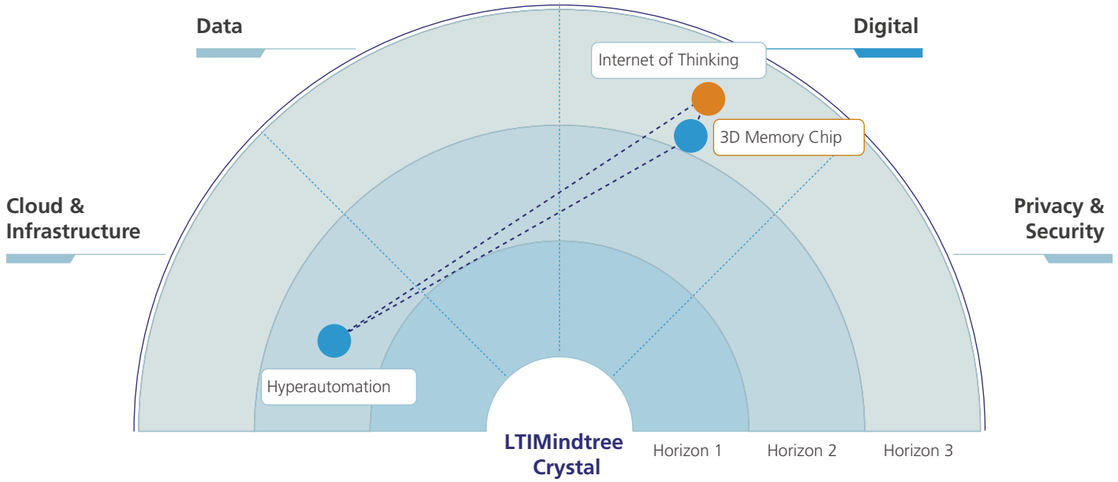
Horizon	Market Potential (USD)	Adoption Phase
Horizon 1	0-100Mn	Emerging
Horizon 2	100Mn-500Mn	Improving
Horizon 3	500Mn–1Bn	Mature
	1Bn–10Bn	
	10Bn +	

CRYSTAL **Insights**

3D memory solutions are evolving rapidly with rising demand for enhanced functionality and miniaturization in **portable hand-held devices.**

Circuit level and structural changes in 3D memory technology are significantly altering how different error sources affect the reliability of the memory.

Radar Positioning & Related Technologies



Overview

3D Memory Chips are a kind of non-volatile flash memory where silicon memory cells are stacked in multiple layers vertically to create a three-dimensional storage matrix. This vertical stacking makes 3D memory chips capable of **greater storage capacity, efficiency, and performance. 3D NAND** can be written in a single pass and requires up to **50% less power than 2D NAND.** Also, the technology can drastically lower the cost-per-byte compared to 2D NAND flash.

3D Memory Chip – **Technology Landscape**(2/2)

How is it a game changer?

The world is witnessing a data explosion, with global data projected to amount to **175 zettabytes by 2025**.

With this staggering rate of data generation, the world needs new data storage solutions, which 3D Memory Chip could provide.

Advancements in **3D NAND** flash will create a world where people will enjoy faster speeds, greater energy efficiency, and improved reliability in the devices they use.

Moreover, the proliferation of **next-generation IoT** technology across the enterprise and residential sectors has significantly aided the development of the 3D Memory market, creating market opportunity for the market's major players.

The global 3D NAND flash memory market is expected to grow significantly during the forecast period due to increasing space constraints on semiconductor wafers.

Key Use Cases

Construction

3D memory stack thermal modeling and design on processor with thermal bridge structure

Technology

3D integration of memory for both memory and processor caches provide a fertile application space for 3D integration

BFS

Inter-bank data transfer using network-on-memory in highly banked memories

Manufacturing

Increasing demand for 3D memory chips in data centers

Featured Story

Data storage leader's secret-weapon chip may become a game changer

A US-based data storage leader made a **USD 250 million investment on a novel and unproven memory technology**. The company revealed that it was licensing its technology for 3D memory and teaming up with a Japanese multinational conglomerate corporation to further develop the technology. The agreement is the first major step by the data storage provider to develop rewriteable 3D memory chips, a technology that could change the game in the **USD 14 billion NAND flash memory** market.

Autonomic Systems – **Technology Landscape(1/2)**

Technology Rating

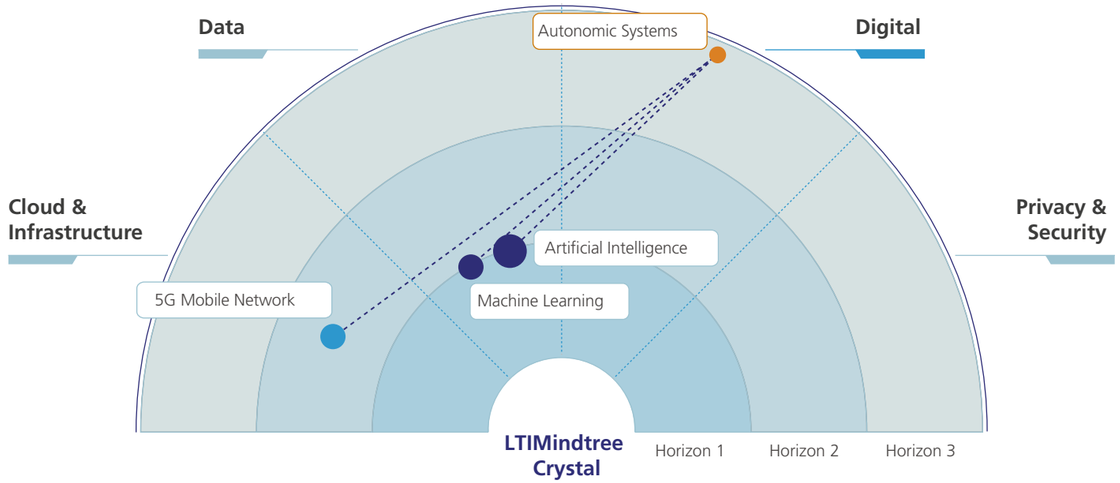
Horizon	Market Potential (USD)	Adoption Phase
Horizon 1	0-100Mn	Emerging
Horizon 2	100Mn-500Mn	Improving
Horizon 3	500Mn–1Bn	Mature
	1Bn–10Bn	
	10Bn +	

CRYSTAL **Insights**

Autonomic Systems are now expanding beyond IT and cyber security applications to include use cases such as smart cities, smart factories, etc.

Advancements in AI, ML, IoT, cloud, virtualization and other technologies will provide possibilities to expand landscape of autonomic systems.

Radar Positioning & Related Technologies



Overview

Autonomic Systems exploit continuous learning and dynamic adaptation to provide **superior automation** of tasks and business processes **in complex and dynamic environments**. IT leaders should exploit their capabilities while managing challenges like nondeterminism. As organizations grow, traditional manual management can't scale at the same rate. Autonomic systems are **self-managing physical or software systems** that learn from their environments. But unlike autonomous or automated systems, they can dynamically modify their own algorithms with no software updates. This allows rapid responses to change, enabling management at the scale of complex environments.

Autonomic Systems – **Technology Landscape**(2/2)

How is it a game changer?

Lockdowns, social distancing, reduced travel, and business flux between 2020 and 2021, combined with rapid digital transformation, reinforced the importance of **autonomic systems** for better automation of tasks and business flows in this highly **dynamic and uncertain environment.**

With the **extremely dynamic market conditions**, and **shifting geopolitical environments**, enterprises in **Asia** and around the world are focusing even more on autonomic systems to stay competitive, agile, employee-centric and customer-centric.

In the post-COVID world, factors such as **shrinking IT budgets**, the increasing importance of load optimization, elasticity, and utilization play an even more critical role.

The growth of **RPA, intelligent automation, IoT, smart cities, 5G and software-defined networks/network virtualization, cyber resilience and security, cloud-native and multi-cloud** are opportunities and necessities for **autonomic systems.**

Key Use Cases

Utilities

Autonomic energy management with fog computing

Transportation

Traffic flow optimization

Minimize the event of oversaturation and spill-back in the network links

Manufacturing

Optimize manufacturing activities at the machine, unit or entire facility

Technology

Information Technology Service Management (ITSM)

Autonomic proactive cyber defence mechanism

Featured Story

F-35 Joint Program Office completes initial deployment of new, improved logistics hardware

F-35 Joint Program Office (JPO), in partnership with an American aerospace and defense technology company, achieved another milestone in the transition of the Autonomic Logistics Information System (ALIS) to the modernized F-35 Operational Data Integrated Network (ODIN) logistics information system by fielding the first 14 sets of new ODIN hardware to F-35 squadrons on schedule, and within budget. They worked together to install the new computer hardware, called the ODIN Base Kit (OBK), at sites in the US and in Europe. This completes the initial phase of ODIN hardware rollout, replacing all first-generation unclassified ALIS servers in the field.

Internet of Behaviour – **Technology Landscape(1/2)**

Technology Rating

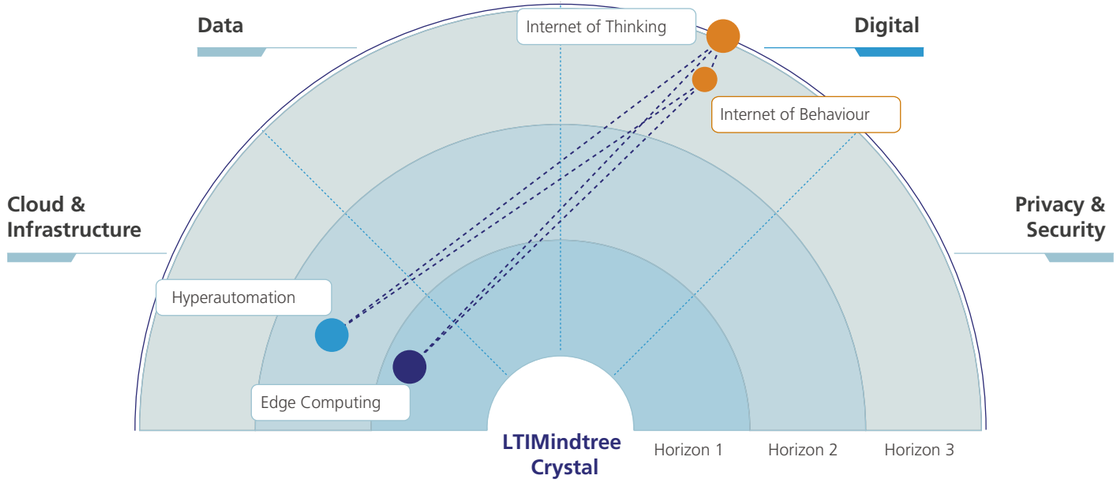
Horizon	Market Potential (USD)	Adoption Phase
Horizon 1	0-100Mn	Emerging
Horizon 2	100Mn-500Mn	Improving
Horizon 3	500Mn–1Bn	Mature
	1Bn–10Bn	
	10Bn +	

CRYSTAL **Insights**

According to Gatner, the IoB technology may still be in its early days, but by the end of 2025, **more than 50% of the world's population will be exposed to at least one IoB programme**, either from the government or a private company.

It will be essential for the businesses implementing IoB to **strike a balance between personalized offerings and intrusiveness** to avoid adverse consumer reaction.

Radar Positioning & Related Technologies



Overview

The Internet of Behavior (IoB) refers to the extraction of critical consumer data from sensors and devices connected to **IoT**. IoB can be thought of as the intersection of data analytics and behavioral economics, powered by IoT capabilities. Analyzing consumers from a behavioral perspective helps businesses optimize their business processes and offer greater value to consumers. **Consumer patterns, interests, and preferences** are the types of IoB-related insights that businesses can leverage.

Internet of Behaviour – **Technology Landscape**(2/2)

How is it a game changer?

IoT changed the way devices speak to one another and can redefine the connectedness of **people, objects, and processes.**

IoB leverages IoT technology and the masses of actionable data it produces to analyze it with the aim of understanding human preferences and decision-making.

IoB enables customer journeys to be tracked to the fullest extent and provide additional touchpoints for reinforcement or purchase decision.

It has the potential to make every milestone stimulating and thus inch customers **closer to decision point favouring** the product.

Service quality and value chain can be significantly enhanced with the help of the data and insights garnered through such an approach.

By becoming aware of where and when the customer is shopping, it may be possible to send real time intimation to customers about the latest value proposition.

Key Use Cases

Life Sciences

Patient diet recommendation

BFS

Enhanced KYC

Channel usage optimization

Retail

Preferential product prioritization

Customer journey customization

Featured Story

A mobile app which aims to promote golf by offering a unique way of learning and improving golf skills

The Ukraine based company built an IoT application that connects to the sensors attached to the golf sleeve, which catches the golfer's wrist and shoulder movements during the swing. This project implements the IoB concept. The essence of the project is to help golfers improve their playing skills with the help of a mobile application and tracking of wearable devices, namely correcting existing ball striking technique and learning new techniques. Making use of a handheld device connected to the mobile phone, each hit on the golf ball is recorded in the app and analysed (stroke force, trajectory, angle, etc.). As a result, the player can see their mistakes and get visual recommendations on how to improve their swing and stroke.

Internet of Thinking – **Technology Landscape(1/2)**

Technology Rating

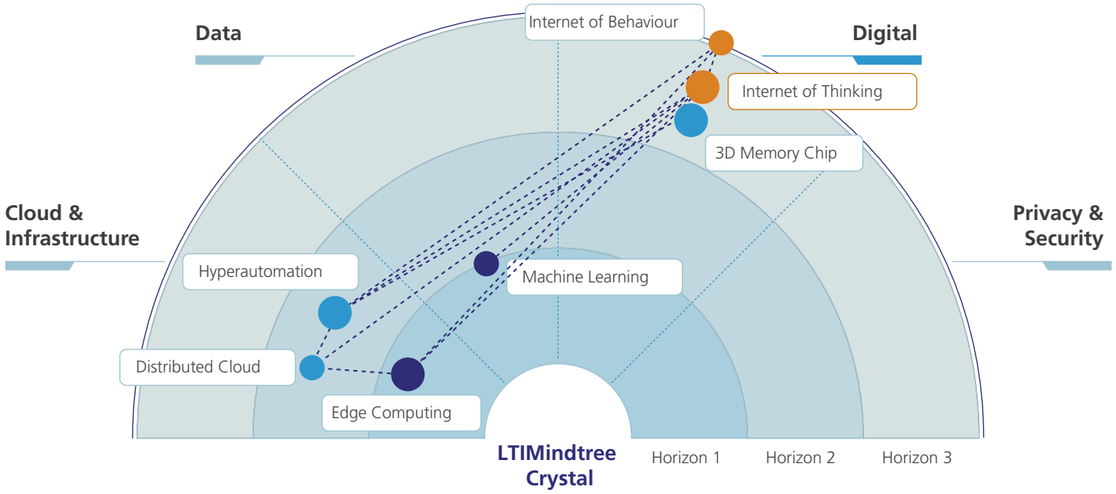
Horizon	Market Potential (USD)	Adoption Phase
Horizon 1	0-100Mn	Emerging
Horizon 2	100Mn-500Mn	Improving
Horizon 3	500Mn–1Bn	Mature
	1Bn–10Bn	
	10Bn +	

CRYSTAL **Insights**

This generation of intelligent solutions will transform physical environments, and companies will need to invest **in infrastructural development and edge computing** to fully take advantage of this technology's capabilities.

The rising need for **real-time signals for proactive maintenance and business decision-making** is expected to drive the demand for this technology.

Radar Positioning & Related Technologies



Overview

Internet of Thinking refers to systems that can process and analyze the data collected by IoT devices closer to the origin of the data without relying on a central cloud server. This technology is focused on maximizing the capabilities of hardware by harnessing a mixture of IoT and edge computing. By implementing analytics capabilities near the data sources, this technology helps stakeholders gain **real-time insights**, allowing them to make **immediate operational adjustments.**

Internet of Thinking – **Technology Landscape**(2/2)

How is it a game changer?

As we are applying more intelligence, it's not just all one centralized big-brain system that's doing this for organizations. Intelligence at the edge in many cases, its off-board or off-line intelligence combined together with different more centralized means. Companies are reinvesting in their infrastructure and are looking at having software accelerators that will help them reach the next level of hardware computer processing. Also being able to provide that instant intelligence that not only customers are demanding, but that a lot of different devices will demand.

Intelligent infrastructure and interconnected systems with analytical and real-time data transmission capabilities will transform many industries. The unique selling point of this technology is its ability to manage change autonomously to optimize work processes, reduce costs and increase productivity. This integration of intelligent solutions with IoT will transform physical environments. Companies are investing in **infrastructural development** and **edge computing** to fully take advantage of IoT network.

Key Use Cases

Media & Entertainment

- Real time content IP violations detection
- Ambient content censoring

Life Sciences

- Neuropace device
- Pro-active emergency alerts

BFS

- Micro-trading regulations
- Edge secure financial services

Retail

- Cashier-less shops
- Intimate view of customers' needs and interests

Featured Story

CLS-Ready certification to secure Internet of Thinking Things (IoTT) devices

OPTIGA Trust M, a high-end security solution that provides an anchor of trust for connecting IoT devices to the cloud, received the **CLS-Ready certification from the Cyber Security Agency of Singapore (CSA)**. As the number of IoT devices increases, so does the number of cyberattacks worldwide. However, the security of **Internet of Things (IoT) and Internet of Thinking Things (IoTT)** devices is very frequently overlooked until it is too late and attackers manage to compromise the devices. To address the increasing cybersecurity threats, the CSA launched the Cybersecurity Labeling Scheme (CLS) in 2020.

Quantum Computing – **Technology Landscape(1/2)**

Technology Rating

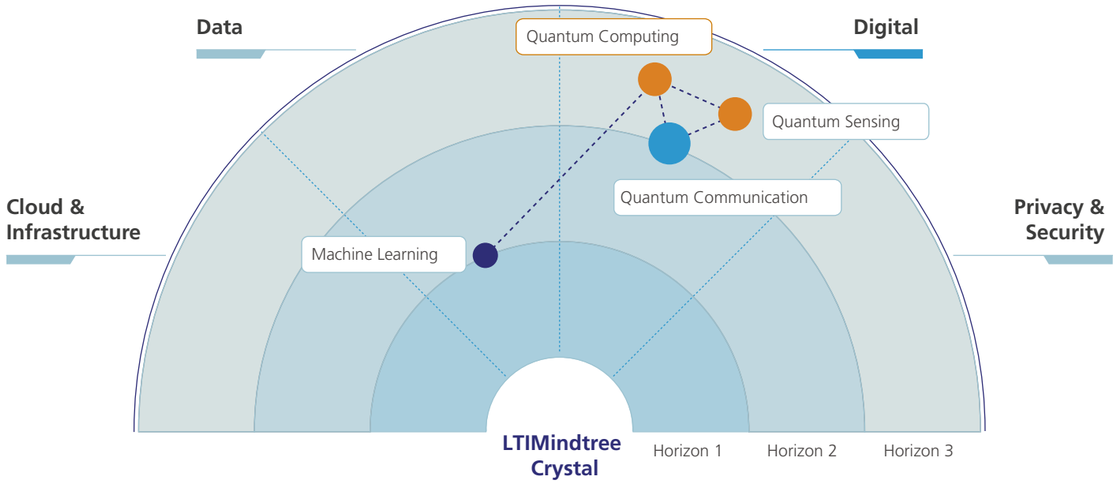
Horizon	Market Potential (USD)	Adoption Phase
Horizon 1	0-100Mn	Emerging
Horizon 2	100Mn-500Mn	Improving
Horizon 3	500Mn–1Bn	Mature
	1Bn–10Bn	
	10Bn +	

CRYSTAL **Insights**

Quantum Computing is one of the improving technologies and is predicted to have one of the highest market potentials in the near future.

It can provide critical breakthroughs in areas including AI, ML, cryptography, and optimization.

Crystal Positioning & Related Technologies



Overview

Quantum Computing is the process of **leveraging quantum mechanics** as a means of processing information. This technology **utilizes atoms, ions, photons, or electrons** instead of binary code, allowing information to be processed in a very different way to traditional computers. The capabilities of Quantum Computing include solving problems involving complex variables with a multitude of potential outcomes. Quantum Computing devices will handle information more fundamentally than "classical" devices like smartphones, laptops, or even today's most powerful supercomputers.

Quantum Computing – **Technology Landscape**(2/2)

How is it a game changer?

Gartner rates quantum computing as the decade's most disruptive technology and believes that **40% of large companies** are planning to create initiatives around quantum by 2025.

China has demonstrated application in communications. Using Quantum Computing they have created an ultra-secure data link between two ground stations separated by more than 1,000 miles.

We are currently in the Noisy Intermediate-Scale Quantum era where the number of qubits is small (100-150 qubits) and lack error correction to perform complex computations but large enough to demonstrate the quantum advantage.

In 2021, IBM unveiled their 127-qubit, Eagle quantum computer. They are first to break the 100-qubit barrier mark.

Quantum Computing could create value in the range of **USD 450 Bn to USD 850 Bn** in the **next 15 to 30 years.** BCG estimates that quantum optimization applications in finance, logistics, and aerospace alone could generate up to **USD 220 Bn** in annual revenue.

Key Use Cases

Automotive

- Optimizing large autonomous fleets
- Quantum simulations
- Reduce manufacturing Cost

Pharma

- Drug development
- Cancer treatment by analyzing genetic data

Chemicals

- Material discovery & development
- Improve catalyst design

Logistics

- Vehicle routing
- Knapsack problem

Featured Story

Quantum consulting startup collaborates with chemical company on quantum compute-powered weather modeling

A France-based full-stack neutral atom quantum computing provider, and a **Germany-based** multinational **chemical company**, partnered to introduce weather modeling and other computational fluid dynamics applications. The problem space relies on solving complex nonlinear differential equations, a task for which, it turns out, **quantum solution provider's hardware and algorithms are especially well-suited.** Its hardware platform implements qubits (quantum bits), using individually trapped atoms that are manipulated with lasers, and the company produces 100-qubit systems today. The neutral atom platform supports something called "analog mode," which enables addressing all of those qubits concurrently, thereby enabling an important quantum computing behavior called entanglement, where multiple qubits act as a single system and influence each other.

Quantum Sensing – **Technology Landscape(1/2)**

Technology Rating

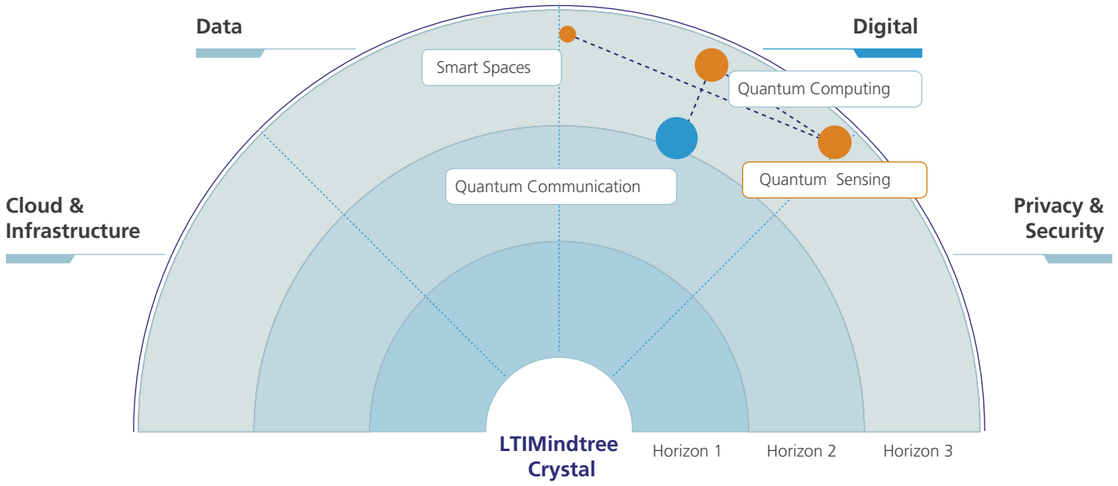
Horizon	Market Potential (USD)	Adoption Phase
Horizon 1	0-100Mn	Emerging
Horizon 2	100Mn-500Mn	Improving
Horizon 3	500Mn–1Bn	Mature
	1Bn–10Bn	
	10Bn +	

CRYSTAL Insights

Quantum Sensing exploits the properties of quantum mechanics to develop ultra-sensitive technology that can detect changes in electric and magnetic fields & motion.

Quantum Sensing is a far-reaching field that is rapidly approaching the market.

Radar Positioning & Related Technologies



Overview

Quantum Sensing describes the use of a quantum system, quantum properties or quantum phenomena to perform a measurement of a physical quantity. **Historical examples** of quantum sensors include **magnetometers** based on **superconducting quantum interference devices and atomic vapors, or atomic clocks.** Quantum sensing is growing, with the most common platforms being spin **qubits, trapped ions and flux qubits.**

Quantum Sensing – **Technology Landscape**(2/2)

How is it a game changer?

Quantum sensing can be used to realize unprecedented **combinations of range, resolution, and sensitivity for measurements of critical parameters of interest.**

Data from sensor devices with high sensitivity and reliability that can detect early signs of equipment failure can be analyzed using predictive models to obtain insight on future performance and assess the **operational state of health** with a higher degree of confidence. Such enhanced monitoring systems enable condition-based asset maintenance rather than time-based maintenance, thereby lowering the overall cost and minimizing interruptions and failures.

Quantum sensors, are providing qualitatively new data about our world, which can be turned into valuable information about our environment. This will underpin advances in everything from autonomous transport, navigation and brain imaging to Internet of Things. Quantum technology gravity sensors, can theoretically, detect all the way to center of the earth.

Key Use Cases

Manufacturing

Detect early faults in equipment

Electricity delivery transmission, distribution, and storage

Life Sciences

Fluorescence lifetime measurement technique, based on near-field or confocal microscopy

Singlet oxygen detection

Automotive

Secure communication & 5G networks

LiDAR, a method of detecting and ranging an object by reflected light

Defense, Security & Aerospace

Free space communication

Quantum Key Distribution to secure data against classical & quantum threats

Featured Story

UK-based photonics technology company raised GBP 12 million (USD 14 million) for its quantum sensing technology

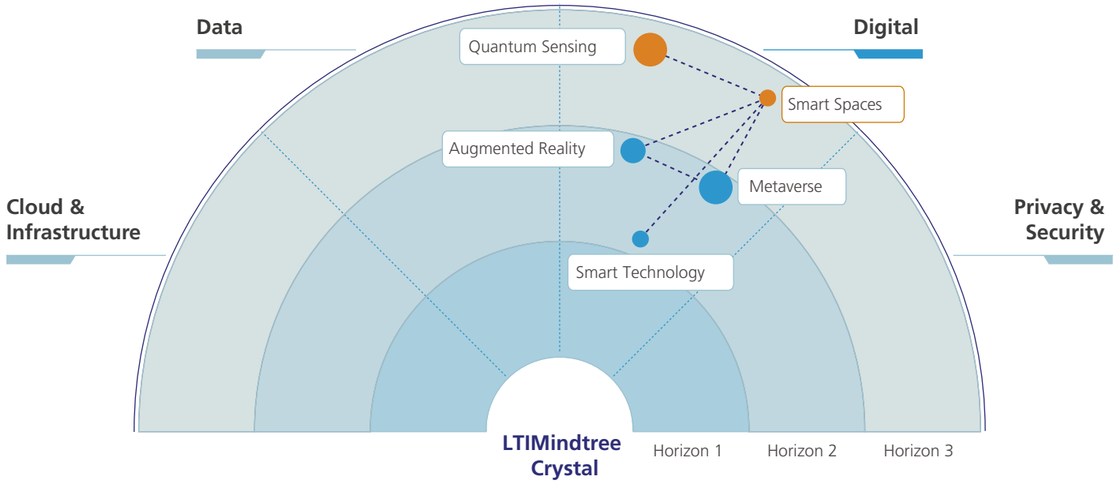
A UK-based photonics technology company has developed a laser sensor based on quantum technologies that can measure small emissions of methane, a major greenhouse gas. The Series-A funding includes a collaboration agreement with an oilfield leader, where the startup's technology will be part of an oilfield customer's end-to-end emissions solutions business offering for the oil and gas industry.

Smart Spaces – **Technology Landscape**(1/2)

Technology Rating

Horizon	Market Potential (USD)	Adoption Phase
Horizon 1	0-100Mn	Emerging
Horizon 2	100Mn-500Mn	Improving
Horizon 3	500Mn–1Bn	Mature
	1Bn–10Bn	
	10Bn +	

Crystal Positioning & Related Technologies



CRYSTAL Insights

Cloud-based Smart Space solutions will enable smart solution providers to manage all their analytics needs in a cost-effective and efficient manner, accelerating the technology's growth.

Implementation of smart space is increasing in **government and public spaces** where security is crucial for public safety.

Overview

Smart Spaces are physical environments infused with technology. Smart spaces are **interactive environments** where **human and technology** can **openly communicate** with each other **in a physical or digital setting**. This enables "a more immersive, interactive and automated experience for a target set of people and industry scenarios." Examples of smart spaces include smart cities, smart homes, and smart factories. With technology taking over our everyday lives, it's no wonder why the **eighth trend** on **Gartner's top 10 trends** list is smart spaces, the ultimate immersive experience.

Smart Spaces – **Technology Landscape**(2/2)

How is it a game changer?

According to Forrester, a lot of companies are heavily investing into smart spaces. In 2022, smart infrastructure investments are expected to **increase by 40%,** powered by large government spending windfalls in smart infrastructure in **China, Europe, and US.**

Smart Spaces also have a **relation** with the **Real-World Metaverse** which provides a digital layer with smart enhancements on top of our physical world. The Real-World Metaverse and **AR Cloud** establish the link between the digital smart spaces with its physical counterpart providing position of the digital data in the physical world.

Robotics also play an important role in tandem with smart spaces and the Real-World Metaverse. Real-World Metaverse together with a cell phone and a capable robot would allow sharing the same spatial map between each other.

Key Use Cases

Media & Entertainment

- Better recommendation engine
- Real-time predictive modeling for demand prediction and segmentation

Retail

- Customer modeling and simulation
- Avoiding interruptions in the supply chain

Life Sciences

- In-patient and remote monitoring and rehabilitation

Manufacturing

- Operation management
- Predictive maintenance

Featured Story

Consumer electronics manufacturer launches a smart meeting room management solution for seamless workplace experience

A multinational consumer electronics and home appliances manufacturer launched a **smart meeting room management solution** to help organizations efficiently manage workspace usage. The solution offers both hardware and software capabilities that assist to optimize meeting room space. It is the only wireless meeting room management solution in India that is based on energy-efficient technology by a pioneer in ePaper technology with unparalleled battery life. The solution is compatible with all e-mailing platforms accessible on laptops and smartphones.

Spatial Computing – **Technology Landscape(1/2)**

Technology Rating

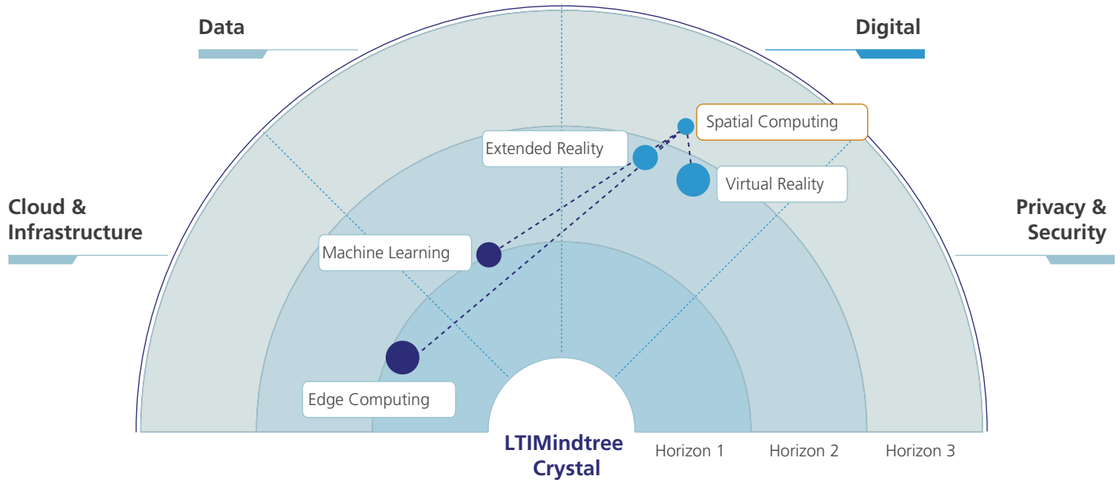
Horizon	Market Potential (USD)	Adoption Phase
Horizon 1	0-100Mn	Emerging
Horizon 2	100Mn-500Mn	Improving
Horizon 3	500Mn–1Bn	Mature
	1Bn–10Bn	
	10Bn +	

CRYSTAL **Insights**

Spatial computing is at an **improving stage,** and it is commonly used in **GPS, wearable devices and ride-sharing applications.**

This technology is expected to expand its applications in **healthcare, manufacturing and automotive** industries with evolutions in AR/VR and 5G technology.

Crystal Positioning & Related Technologies



Overview

Spatial Computing is human interaction with a machine in which the machine retains and manipulates referents to real objects and spaces. **VR** and **AR** are probably the two technologies most likely to be associated with spatial computing. With spatial computing, developers and designers can explore the world of XR or mixed reality, where we manipulate digital information in a non-digital format. Spatial computing **offers** a huge **range of technology options** to step into, **from haptic feedback systems, to edge computing, machine learning, robotics, and IoT.**

Spatial Computing – **Technology Landscape**(2/2)

How is it a game changer?

Spatial computing provides **dynamic 3D visualization in real time of products, industrial spaces**, and workers and all their interactions.

Hospital researchers are experimenting with everything from remote surgeries to ways of projecting X-rays or **scans directly on to patients.** Teams at both the Technical University of Munich and Johns Hopkins University researching on computer-aided medical procedures are building a tool that allows consultants to generate virtual avatars, to guide colleagues remotely.

They aim to create a 3D digital duplicate of an operating room and everyone in it, giving a perspective even from inside the patient's body. With virtual and augmented reality, one is not required to go physically into the operating room and can put on a head-mounted display and see five surgeries in a night.

Key Use Cases

Enterprise

Remote collaboration & real-time communication

Training, learning and development

Security

Prevention against cyberattacks

Life Sciences

MRI CT Scan data to be displayed on patient's body to provide live feedback to doctor

Manufacturing

Spatial analytics for work-force performance measure-ment

Featured Story

AR company upgrades its Spatial Mapping Platform

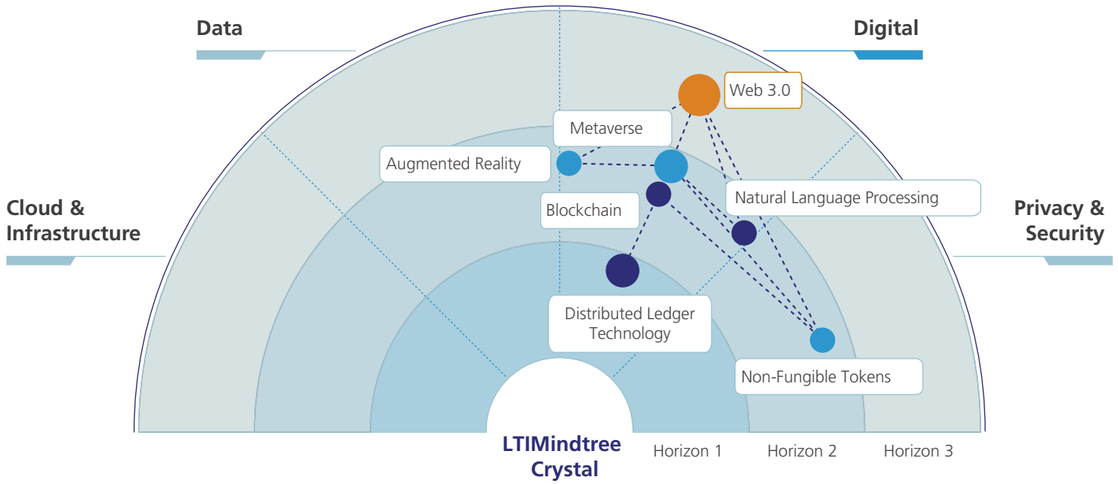
A Canada-based AR solutions provider upgraded its spatial computing platform for the **real-world metaverse** that drives **new revenue for properties and brands** with out-of-the-box **AR** mapping solutions. The company's spatial computing and the spatial web will have unlimited potential and use cases including healthcare, education, sports venues, hospitals, campuses, trade shows, theme parks, airports, museums, warehouse wayfinding, and entertainment forever changing world into a metaverse with spatially aware computers.

Web 3.0 – **Technology Landscape**(1/2)

Technology Rating

Horizon	Market Potential (USD)	Adoption Phase
Horizon 1	0-100Mn	Emerging
Horizon 2	100Mn-500Mn	Improving
Horizon 3	500Mn–1Bn	Mature
	1Bn–10Bn	
	10Bn +	

Crystal Positioning & Related Technologies



CRYSTAL **Insights**

Web 3.0 can potentially change the **future of Internet, and traditional business world** into a digital space.

Developments in Web 3.0 will help entities to find their target audience and customers online by giving them a new user experience.

Overview

Web 3.0 represents the next iteration or phase of the evolution of the web/internet and potentially could be disruptive and represent a paradigm shift. Web 3.0 is built upon the **core concepts of decentralization, openness,** and **greater user utility**. Web 3.0 has the potential to provide users with far greater utility, going well beyond the social media, streaming, and online shopping. **Capabilities** like **Semantic Web, AI,** and **ML**, which are at the core of Web 3.0, have the potential to greatly increase application in new areas and vastly improve user interaction.

Web 3.0 – **Technology Landscape**(2/2)

How is it a game changer?

Web 3.0 solves the issues associated with **centralization of data storage and communication services.** To reiterate, users did not actually control or own the data they produced. Moreover, the centralized web is also conducive to censorship and de-platforming. Web 3.0 returns the control over data to users, who remain in charge of storage and communication.

Websites on this user-centric version of the web run on blockchain networks, replacing centralized servers with thousands of globally distributed computers. The **space** is seeing huge interest from tech disruptors globally, with **Indian app Chingari** being one of the leaders in the proliferation of Web 3.0.

Manufacturing, BFS, healthcare, logistics, gaming, social media, travel and airline industries, and many more can benefit from Web 3.0 by utilizing blockchain for cryptocurrency for quicker transactions, setting up automation with smart contracts, providing **secure records for customers and patients, secure contracts, smart contracts for automation** and many more.

Key Use Cases

Media & Entertainment

- Community owned production houses
- Micro-subscription models

Life Sciences

- Interoperable electronic health record

BFS

- Micro payments
- Open banking in Web 3.0
- DeFi

Technology

- Decentralized identity
- Metagovernance

Featured Story

A global cryptocurrency platform launches Web 3.0 wallet and EUR trading

A Seychelles-based cryptocurrency platform launched its **wallet app** to redefine the concept of decentralized wallets, offering users a **unique Web 3.0 experience.** Its wallet is being positioned as a **user-friendly, secure, and professional** Web 3.0 wallet designed for easy decentralized web exploration. The application allow users to quickly create decentralized accounts, thus reducing barriers to entering Web 3.0 and giving them the ability to explore popular Apps across various public chains, including games and financial services. In addition to the launch of Wallet, the crypto platform has expanded its offering to include EUR trading against Bitcoin (BTC), Ethereum (ETH) and United States Department of the Treasury (USDT) to conquer the European market.

Back to Navigation

Decentralized Identity – **Technology Landscape(1/2)**

Technology Rating

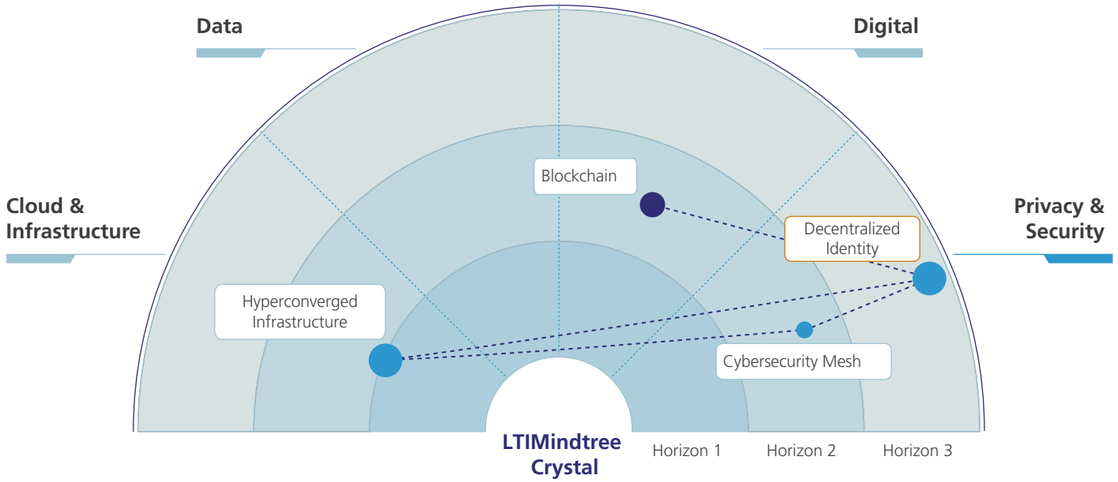
Horizon	Market Potential (USD)	Adoption Phase
Horizon 1	0-100Mn	Emerging
Horizon 2	100Mn-500Mn	Improving
Horizon 3	500Mn–1Bn	Mature
	1Bn–10Bn	
	10Bn +	

CRYSTAL **Insights**

The adoption of decentralized identity is a promising technology for Identity Access Management (IAM) and rapidly evolving with a self-sovereign network.

This technology is still at the early phase of development and needs to address regulatory and compliance issues for acceptance at an industrial scale.

Crystal Positioning & Related Technologies



Overview

Decentralized Identity is a the concept that gives back **identity control** to consumers through an identity wallet in which they collect verified information about themselves from certified issuers (such as the government). By controlling what information is shared from the wallet to requesting 3rd parties (e.g., when registering for a new online service), the user can **better manage their identity online and their privacy**. A decentralized identity approach helps **people, organizations, and things** interact with each other transparently and securely, in an **identity trust fabric**. The benefits of decentralized identity grow with the number of businesses and individuals that use it.

Decentralized Identity – **Technology Landscape**(2/2)

How is it a game changer?

In order to provide customers with a seamless and safe user experience, both the **public and commercial** sectors are already utilizing the true potential of **decentralized authentication**. The risk of identity theft is further decreased by the growing adoption of **decentralized identification**, which eventually eliminates the requirement for **storing user credentials across several websites.**

Decentralized Identity helps organizations to gain the **trust of customers by reducing identity fraud and the risk of identity theft.** It ensures **quick and efficient verification of the authenticity of data by third-party.**

The technology offers adequate security to protect **the personal and sensitive information (credit card details, medical information, etc.)** of customers. It reduces **the compliance burden** on organizations to manage clients' private information.

Key Use Cases

Life Sciences

- Streamline information exchange between patients, hospitals, insurers, and families
- Verify staff and vendors' credentials

BFS

- Virtual verification of customer data
- Compliance with new regulations and policies

Government

- Protect constituent records and personal information using cryptography
- Securely manage credentials of citizen

Insurance

- Instantly verify customer data
- Provide customer with a verifiable credential

Featured Story

US-based decentralized credit bureau launches test-net of its decentralized identity solution

A US-based hybrid credit protocol and decentralized credit bureau launched its first **soulbound identity in web3**. The revolutionary new Web3 identity credential will make it easier for users globally to establish a Web3 financial identity and confirm patterns of creditworthiness using **10,000+ -Web2 and Web3** data sources in **78 countries**. With this web3 financial identity established, users globally can get access to decentralized loans and other financial products. Lenders will be able to increase underwriting quality and access a global pool of decentralized liquidity. Liquidity providers will be able to better assess lenders' loan book quality and make data-driven investment decisions.

DNA Data Storage – **Technology Landscape(1/2)**

Technology Rating

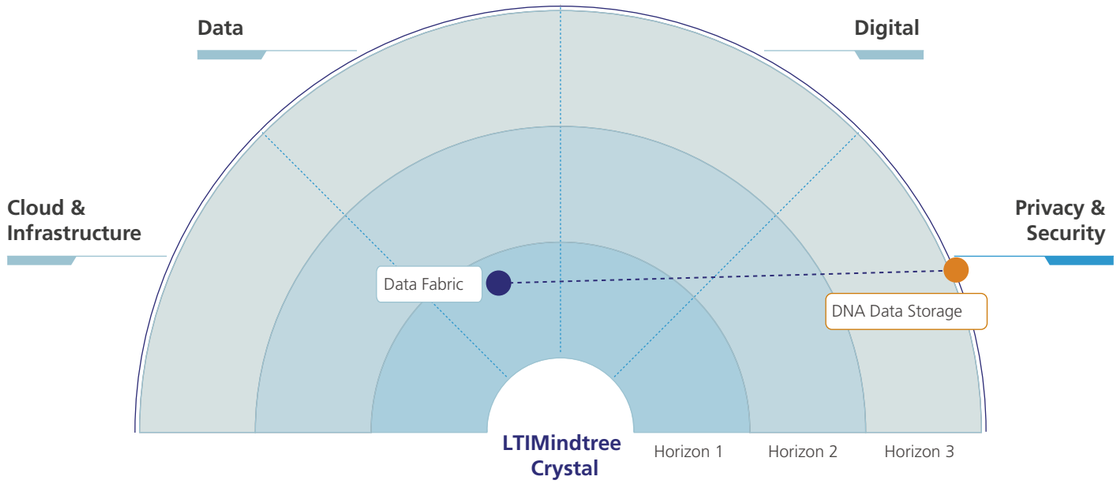
Horizon	Market Potential (USD)	Adoption Phase
Horizon 1	0-100Mn	Emerging
Horizon 2	100Mn-500Mn	Improving
Horizon 3	500Mn–1Bn	Mature
	1Bn–10Bn	
	10Bn +	

CRYSTAL **Insights**

DNA Data Storage is a nascent technology which has the potential to **store information using a fraction of the space of current methods and with greater reliability.**

This technology may attract interest from enterprises requiring vast data storage capabilities in future.

Radar Positioning & Related Technologies



Overview

DNA Data Storage enables molecular-level data storage into DNA molecules by leveraging biotechnology advances in synthesizing, manipulating and sequencing DNA to develop archival storage. As humans' digital activity produces larger amounts of data, scientific researchers are touting DNA storage as a potential solution to storing valuable information. DNA is incredibly stable, easy to replicate, and can hold data for centuries. While making strides in its practical usage, DNA Data Storage technology has notable limitations. For instance, the data-encoded DNA needs to be stored under specific conditions, making the process of preserving DNA-based data very expensive.

DNA Data Storage – **Technology Landscape**(2/2)

How is it a game changer?

Humans are currently producing around **1.15 trillion megabytes of data** per day, and the magnetic tapes that digital data is saved on requires replacing roughly every ten years. By creating storage architecture using items with immutable memory, the **"DNA-Data Storage of Things" (DoT)** ensures the sustainable preservation of large quantities of texts and digital materials.

As cost is the most prohibitive factor, it is likely that large technology companies and university research units will take the lead in exploring the possibilities of this technology.

DNA data storage is rapidly headed from the lab to production. However, because the synthesis and sequencing processes are slow compared to electronic information processing, the only feasible application is archival storage.

Data storage professionals responsible for **archive strategies** should follow developments in the field.

Key Use Cases

Media & Entertainment

Archiving digital media content

Life Sciences

Storing patient data

Archiving patient medical history data

Technology

Store large data in compact space

Improve durability of data

BFS

Storing and archiving bank customer information

Featured Story

Biotech company develops chip for DNA Data Storage

US based biotechnology company is introducing a chip for DNA digital storage. The chip is designed to allow the synthesis of 8.4 million oligos, with up to 170 bases per oligo. To test the chip's storage utility, the company said researchers encoded 100 Mb of mixed data types in the DNA as well as retrieved the encoded data. The chip's active electrode field is set up with a density of over 2.5 million sites per square centimeter. Each electrode site on the chip can be independently controlled and produce a different oligo sequence at each location. The company's scientists have built pipelines and algorithms for data encoding and decoding, along with error correction.

Homomorphic Encryption – **Technology Landscape(1/2)**

Technology Rating

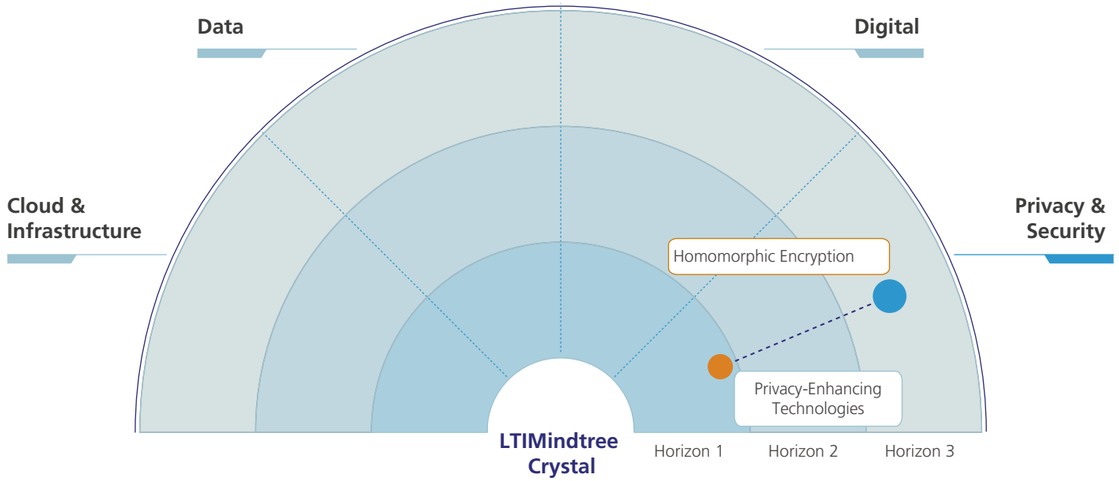
Horizon	Market Potential (USD)	Adoption Phase
Horizon 1	0-100Mn	Emerging
Horizon 2	100Mn-500Mn	Improving
Horizon 3	500Mn–1Bn	Mature
	1Bn–10Bn	
	10Bn +	

CRYSTAL **Insights**

Slow computation speed, lack of standardization and complexity is preventing its adoption and remains commercially infeasible for computationally-heavy applications.

A Privacy-Enhancing Technology, Homomprphic Encryption (HE) offers a tradeoff between data usability and data privacy.

Radar Positioning & Related Technologies



Overview

Homomorphic Encryption (HE) is a form of encryption with an additional evaluation capability for computing over **encrypted data without access to the secret key.** The result of such a **computation remains encrypted.** Homomorphic encryption can be viewed as an extension of **public-key cryptography.** This encryption makes it possible to analyze or manipulate **encrypted data without revealing the data to anyone.** The goal of homomorphic encryption is to create an encryption algorithm that allows an infinite number of additions or multiplications of encrypted data.

Homomorphic Encryption – **Technology Landscape**(2/2)

How is it a game changer?

Increasing usage of cloud services and integration between companies to monetize data is raising concerns over data privacy. Regulations such as the **GDPR, CCPA and HIPPA** aim to protect the privacy of consumers, and businesses pay heavy penalties in case of non-compliance. **Cisco's 2021 Data Privacy Benchmark Study found that 79% of organizations** believe such regulations are having a positive impact.

Homomorphic encryption is an emerging technology that can help businesses to ensure the privacy of their customers without undermining their ability to gain insights from their data. This can allow businesses to leverage cloud computing and data storage services securely. It **eliminates the tradeoff between data security and utility** for businesses.

Thus, HE can allow businesses operating in heavily regulated industries, such as healthcare and finance, to get **outsourcing services for research and analytical purposes** without the risk ofnon-compliance.

Key Use Cases

Government

- Improving election security and transparency
- National/ critical infrastructure security
- Secure contact tracing

Life Sciences

- Patient data privacy
- Sharing sensitive patient data for medical research

BFS

- Consumer data privacy
- Regulatory compliance
- Eliminate fraudulent activities

Retail

- Consumer behavior insights protecting individual data

Featured Story

Korean Crypto startup attracts USD 16 million investment

A Korean crypto startup that holds the **original patent for homomorphic encryption technology**, attracted an investment of about 21 billion won (USD 16 million). The startup developed the original technology for homomorphic encryption "CKKS", the 4th generation encryption technology, and "HEaaN", a product implemented based on it. In 2020, in cooperation with the **country's pension service and a credit risk management company**, the startup built a data statistical model that highly evaluates the credit of those who paid the National Pension Service, making the world's first case of homomorphic encryption commercialization.

Privacy-Enhancing Computation – **Technology Landscape(1/2)**

Technology Rating

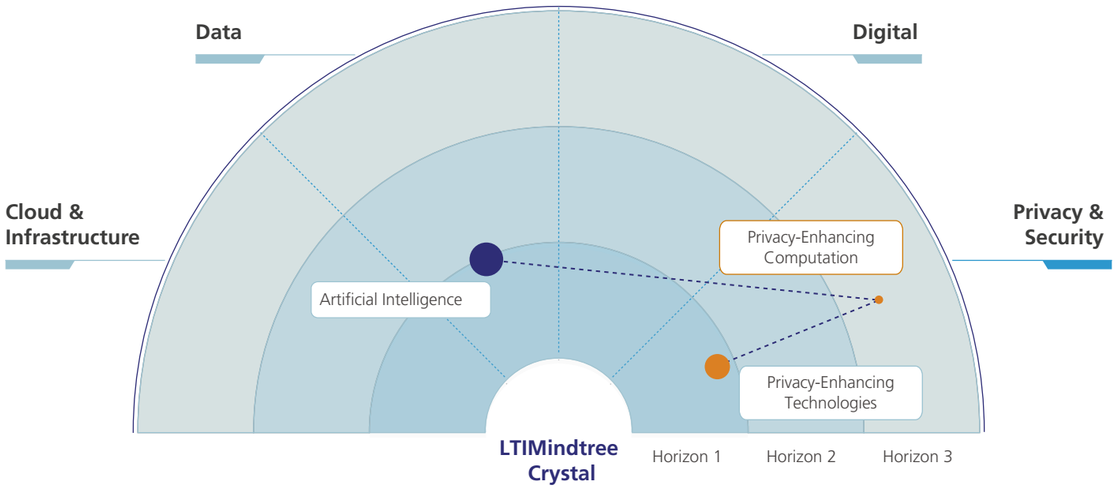
Horizon	Market Potential (USD)	Adoption Phase
Horizon 1	0-100Mn	Emerging
Horizon 2	100Mn-500Mn	Improving
Horizon 3	500Mn–1Bn	Mature
	1Bn–10Bn	
	10Bn +	

CRYSTAL **Insights**

Privacy-Enhancing Computation is at an **emerging stage** and quickly evolving to fulfill the operationalization needs of B2B companies.

Evolution in **homomorphic encryption and differential privacy** will expand PETs applications to enterprise-level organizations beyond academics and governmental use cases.

Crystal Positioning & Related Technologies



Overview

Privacy-Enhancing Computation protects data in use while maintaining privacy or secrecy online common data-at-rest security measures. Gartner defines PEC as featuring three technologies that protect data while it is in use. **These technologies include:**

A **trusted environment where sensitive data** can be processed or analyzed.

Performs processing and analytics in a decentralized manner.

Encrypts data and algorithms before analytics or processing.

Privacy-Enhancing Computation – **Technology Landscape**(2/2)

How is it a game changer?

Unlike common data-at-rest security controls, **PEC** protects data in use. As a result, organizations can implement data processing and analytics that were previously impossible because of privacy or security concerns.

Gartner predicts that **by 2025, 60% of large organizations will use at least one PEC technique in analytics, business intelligence and/or cloud computing.**

Homomorphic encryption is one of the trending techniques in PEC allowing the processing of encrypted data for third-party providers. This technique may expand its applications in sectors like medical, banking, among others, for secure computation of highly sensitive data.

Key Use Cases

Life Sciences

Make patient record both private and securely accessible

Security

Methods for encryption & provision information security

Automated protection for sensitive data

BFS

Fraud analysis

Intelligence operations

Anti-Money-laundering

Featured Story

First Privacy-Enhancing Technology Sandbox in Singapore

The Privacy-Enhancing Technologies (PET) Sandbox launched by the **Personal Data Protection Commission (PDPC)** and the **Infocomm Media Development Authority (IMDA)** in order to assist businesses who, seek to pilot PET initiatives that address typical business concerns. The PET Sandbox, aims to identify with commercial sector participants the best PET to use case fit and their technological limitations to produce guidelines and best practices that would encourage more adoption. PETs may be able to extract value from confidential or proprietary data that companies may be reluctant to share. Businesses have requested help in implementing PET solutions in practical applications as PETs develop and are ready for deployment.

Back to Navigation

Self-Adaptive Security – **Technology Landscape(1/2)**

Technology Rating

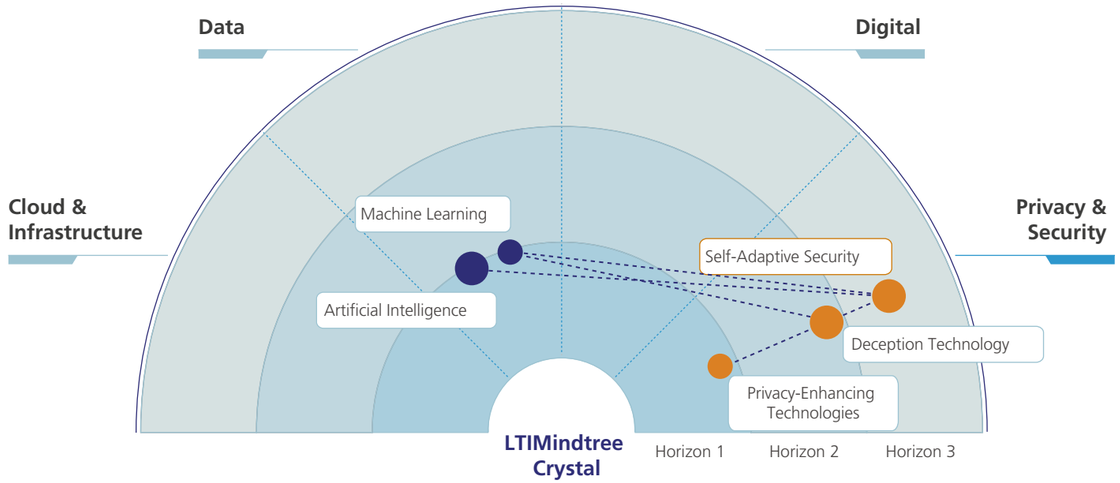
Horizon	Market Potential (USD)	Adoption Phase
Horizon 1	0-100Mn	Emerging
Horizon 2	100Mn-500Mn	Improving
Horizon 3	500Mn–1Bn	Mature
	1Bn–10Bn	
	10Bn +	

CRYSTAL **Insights**

Self-Adaptive Security is an **emerging technology** and security experts are focusing on developing agile and dynamic self-adaptive security model using cloud computing and AI technology.

Rising **digitalization, increasing deployment of IoT and smart technologies** will demand a dynamic model to ensure the security of business and home. This will drive the demand for this security model.

Crystal Positioning & Related Technologies



Overview

Self-Adaptive Security is a security framework that continuously adapts itself in real-time to secure an organization's network infrastructure from advanced cyber threats. This self-adaptive architecture creates a feedback loop to identify, prevent, and respond to threats. Self-adaptive Security relies on technologies like machine learning, multi-factor authentication, biometrics, mobile security, and risk analytics. The technology evolved from traditional security solutions to better adapt to organizations' changing threats and security compliance requirements.

Self-Adaptive Security – **Technology Landscape**(2/2)

How is it a game changer?

Self-Adaptive Security is disrupting the cybersecurity space as the dependency on IT infrastructure continues to grow. The rapid adoption of IoT, big data, automation, and analytics creates the potential for serious cyber threats. Ensuring adequate protection requires a complex security approach.

The **integration of AI and ML** into **Self-Adaptive Security allows** for the **dynamic expansion** of these security capabilities. **In the future,** this technology will form a **vital component** of organizations' **cyber defense measures, safeguarding** their **digital systems** from increasingly sophisticated cyberattacks—with minimal human intervention.

Adaptive security market is expected to witness a **CAGR of 12.7% over the forecast period (2022 - 2028).**

Key Use Cases

BFS

Secure online banking transaction

Safeguard customer's cryptocurrency assets

Life Sciences

Safeguard the healthcare ecosystem

Ensure HIPAA, GDPR, state, and local regulatory

Manufacturing

Secure cloud and protect plant, assets and air-gapped operational technology networks

Government

Ensure remote worker security

Protect vital operations and sensitive information

Featured Story

Cybersecurity partnership to revolutionize patch management and deliver autonomous vulnerability assessment, prioritization, and remediation

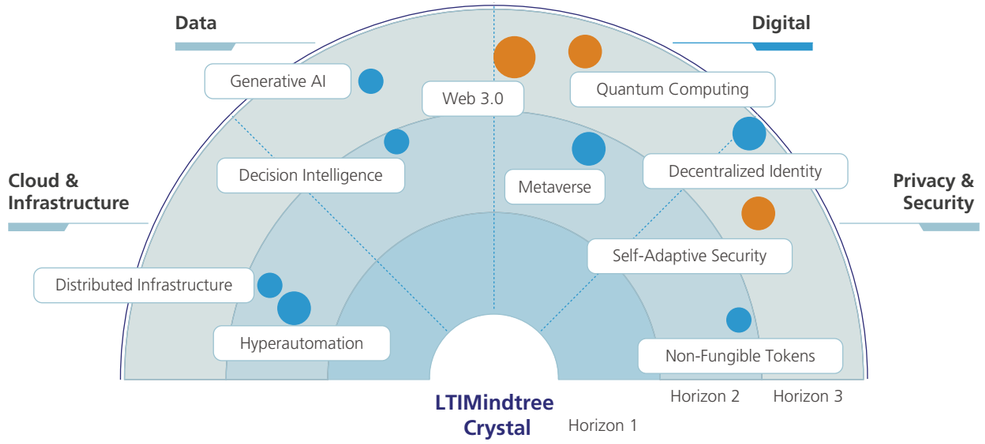
A US-based provider of self-secure platform and an autonomous cybersecurity platform company, joined forces to help organizations adopt a comprehensive, risk-based approach to patch management and bolster cybersecurity against cyber threats, including ransomware attacks. Both the companies will integrate their best-in-class technologies – including patch management and XDR platform to deliver vulnerability assessment, prioritization, and remediation at machine speed.

LTIMindtree Crystal – **Technologies for Tomorrow**

This is our first publication of Technology Radar which demonstrates where various technology trends lie on the horizon and the position of these technology trends based upon their maturity level from conception to a near-derived state. It presents exciting opportunities for the future and helps in decision making to evaluate existing and emerging technology trends. While the future is exciting, I believe there will be challenges and obstacles which can be further researched if we propitiously prepare for them and plot the necessary groundwork to address them.

For an unbiased opinion, I have selected ten technology trends from the LTIMindtree Crystal, based on Horizon **(Horizon 2 and 3)**, market potential **(~USD 1 Bn & above)**, and technology maturity **(Emerging & Improving)**. I anticipate these trends have higher potential and will yield more rewarding opportunities for the industry.

Technologies for Tomorrow



While we have published Deep POVs for few trends, Deep POVs on the other topics are being selected and scheduled for consumption within this year.

In the end, I would like to thank all our contributors in shaping this report which reflects our LTIMindtree values and celebrates our spirit of GRIT.

Sunil Agrawal
Associate Vice President, Global Head of Enterprise Architecture Group, LTIMindtree

Technologies for Tomorrow - **Cloud & Infrastructure**

Hyperautomation

As we all know, automation has been an integral part of various digital transformation initiatives. Previously, automation was solely implemented in driving very specific initiatives like in operational level automation, robotics process automation, etc. All these transformation initiatives were technology centric.

Gartner has recently refined its hyper-automation definition as **"a business-driven, disciplined approach that organizations use to rapidly identify, vet and automate as many business and IT processes as possible."** My key interpretation here is to encourage greater business-driven automation across the board. For instance, a customer journey involves different steps like marketing, running campaigns, customer's onboarding interactions, sales, order, provisioning/delivering products & services to customer support services.

Hence, according to me, hyper-automation will not only include identifying automation opportunity across a given journey but also ancillary processes to achieve the strategic objective of the organization. This trend has improved significantly and will only mature from here as supporting technologies like AI, Robotics etc. mature.

Distributed Infrastructure

In the past, enterprises used to align with only one cloud provider for all their scalability needs. However, the current scenario is very different.

Today, enterprises adopt **multi-cloud strategy along with limited on-prem applications** to avoid vendor lock-in and maximize infrastructure flexibility. Today's cloud providers also offer various cloud native services for deploying cloud native applications at enterprise level.

There are certain challenges that have emerged due to this multi-cloud strategy. Firstly, the complexity has increased significantly, as enterprise-wide applications are now distributed across various infrastructure. It is difficult to obtain enterprise-wide dashboard across such a diverse infrastructure.

The other challenge that persists, is smooth application and data integration across such a Distributed Infrastructure. I strongly believe that for service providers like LTIMindtree, it provides great opportunity to mature solutions around it as challenges around it emerges before it becomes seamless for enterprises.

Technologies for Tomorrow - **Data**

Decision Intelligence

Modern day enterprises are complex due to matrix operation modules. The complexity can be attributed to the enterprise's mutual dependence on other segments of the ecosystem and nature of work they perform. Decision making also becomes difficult due to these complexities. Individual personalities, and biases therein, limit the assessment of the situation objectively.

This leads to creating a **framework for decision making** that has configurable list of parameters with their individual weightage along with ability to perform multiple What-If scenarios is needed. Then, the next logical step will be an **AI based model that evaluates scenarios and provides recommendations** with rationale. The ML algorithms that keep track of past decisions and their subsequent impacts make the Decision Intelligence a trusted companion, helping leaders take decisions objectively. While enterprises have adopted some of its decision making, reliability on these decision intelligence model will only improve as the maturity of AI model and data quality technology improves. And then some of these decisions will be automated to reduce human intervention.

Generative AI

We know that the Generative AI uses unsupervised learning algorithms to generate novel images, audio, video, text, or code. The advent of Generative AI is fuelled by rapid advancements in neural networks and machine learning algorithms for data crunching and pattern analysis.

Even though Generative AI is still at a nascent research phase, I believe trial applications have exhibited spectacular results that might rival human competency. Natural language processing has emerged as a crucial component in Generative AI in terms of **evaluating how humans create and interpret content**.

Despite significant progress, market continues to remain fragmented with no clear directives. Generative AI is offering a conducive climate for budding start-ups. Start-ups are heavily invested in research phase while large service providers are now leveraging some of these products for solving use cases especially Healthcare and entertainment Industries. With increased research and sophistication, I can see that many more industries will leverage it in next 2-3 years.

Technologies for Tomorrow - **Digital**

Metaverse

This is amongst the newer areas of technology that has caught the attention across multiple domains and at an accelerated pace. While Facebook simply defined metaverse as “a set of virtual spaces where you can create and explore with other people who aren’t in the same physical space as you”, we don’t think it has fixed set of features or attributes where you create a **digital platform to connect and interact with people in 3D forms virtually.**

This trend needs to be researched, invested extensively along with Web 3.0 where decentralized internet services will provide more power to its users controlling data they own and share.

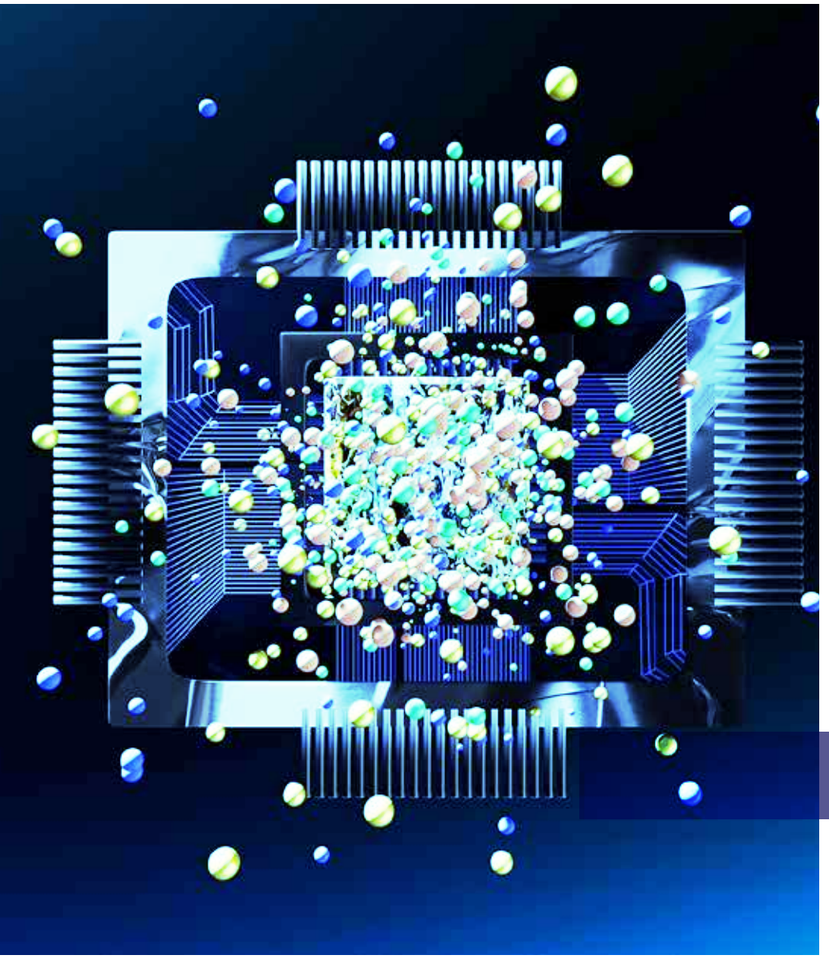
There are multiple business use cases which are coming up and getting prototyped at a very rapid pace as surrounding technologies required to realize metaverse have evolved & are being adopted faster in last decade e.g., AR/VR, AI, decentralized identity, NFT, decentralized payment platform. Hence business leaders should start embracing this technology to enhance their customer experience by **inventing new interaction models.** The global Metaverse Market is estimated to reach **USD 758.6 billion** by the year 2026, growing at a **CAGR of 37.1%.**

Web 3.0

Web 3.0 has moved well beyond this original concept of Decentralized and Semantic Web. We believe that Web 3.0 projects can be complete gamechangers. bringing to users a **fairer internet by enabling individuals to become stakeholders** on the internet, like that of a peer-to-peer network.

While web 3.0 is still very new and there are a lot of emerging players and VCs are investing in the ecosystem, it is majorly within start up community, enterprises and government needs to incubate use cases and increase its adoption to bring this into mainstream. Hence any investment made today will lead to substantial ROI in times to come. The Web 3.0 Metaverse and Commerce stands as an opportunity for businesses to start with.

Technologies for Tomorrow - **Digital**



Quantum Computing

This trend has picked high level of investment in last two years. Almost every week there is news around quantum computing by large players like Google, IBM.

All major countries are investing billions of dollars in quantum R&D. High amount of government funding has caused a lot of academic researchers to take up quantum as part of Ph.D. programs in partnerships with enterprises and government organizations.

On Oct 23, 2019, Google announced it performed a calculation on a quantum processor in 300 seconds that would be impractical with the algorithms available at the time.

While a lot of academics have started writing quantum algorithms for various problems, we must be patient till quantum computers becomes readily available. They are said to be the **most disruptive technology of this century.**

In 2019, IBM also unveiled their 127-Qubit Quantum processor and by 2023, IBM expects to have a 1000 qubit processor.

At LTIMindtree, we are collaborating with IIT Madras and IBM on Quantum technologies by investing in building capabilities in quantum computing. In future, this would be an area which large enterprises would look to solve their complex business problems.

Technologies for Tomorrow - **Privacy & Security**

Decentralized Identity

Decentralized identity (DID), also referred to as "self-sovereign identity" (SSI), is an open standards-based identity framework that uses digital identifiers and verifiable credentials that are self-owned, independent, and can enable trusted data exchange. DID is currently being considered as an alternative to current traditional centralized and federated infrastructure. To simply put, it enables individual to manage its own identity.

Decentralised identity gives **back control of identity to consumers using an identity wallet** in which they collect verified information about themselves from certified issuing authorities (such as the Government, Employer, University, Financial Institutions etc.).

By controlling what information is shared from the wallet to requesting 3rd parties (e.g., when registering for a new online service), the user can better manage their identity online and their privacy. For instance, only presenting ID proof that states that you are over 18 without disclosing your actual date of birth.

W3C, DIF and other organizations are providing base framework and standards for implementation of Decentralized Identities. With **Web 3.0 coming up, decentralized identity would become a necessity.**

Self-Adaptive Security

Security implementation protocols must evolve in direct proportion to the rate of transformation of the system. As cyber-attacks are on the rise, automatic early detection of threats is the need of the hour.

Automatic security mechanism will help in preventing data theft and network interference. With the growing number of Internet-based devices, particularly multimedia devices, it is critical to build **self-adaptive security mechanisms.** These mechanisms will leverage artificial intelligence and machine learning technologies to continuously monitor, detect, and mitigate future attacks.

Enterprises can no longer rely on traditional security systems to protect today's complex ecosystem. It must fast track the adoption of self-adaptive security mechanisms and bring it to horizon 1.

Despite multiple research publications and theories available today, this technology lacks maturity. The implementation also must work across networks and continuously adapt to newer threat and vulnerabilities on the go. However, we must be cautious during its implementation and ensure that latency is not increasing. Rise in latency will certainly hamper the system throughput.

Technologies for Tomorrow - **Privacy & Security**

Non-Fungible Tokens

Non-Fungible Tokens are essentially digital tokens which are unique and irreplaceable like an autographed book, real estate, or an original painting. NFTs represents ownership, authenticity, and origin of unique items.

It allows you to buy and sell these items and keep track of the owner through blockchain. Use cases such as tokenizing patents or IP rights will allow owners to commercialize them in open market. NFTs will bring more **transparency in terms of ownership across the entire supply chain life cycle.**

An NFT can either be one-of-a-kind, like a real-life painting, or one copy of many, like trading cards, with the blockchain keeping track of who has ownership of the file. Currently digital art is the most common use of the NFT.

NFTs have been making headlines lately, some selling for millions of dollars, with high-profile memes like Cyan Cat and the "deal with it" sunglasses being put up for auction. However, for enterprise use cases, questions such as risk, security and governance need to be answered. ERC-721 Non-Fungible Token Standard is the mainstream standard being used here.

Acknowledgement

We would like to thank our Technology Council members for their passion, and support and for taking time out to share their ratings and feedback. This report was an outcome of a close collaboration between the Global Technology Office (GTO), Technology Council, and our Corporate Marketing team.

For any queries and suggestions, please write to **GTO_Crystal@LTIMindtree.com**

Contributors - Technology Council

Anand Rajagopal
Principal Director,
Media & Entertainment, LTIMindtree

Bharat Trivedi
Principal,
Enterprise Architecture Group, LTIMindtree

Kedar Deo
CTO, Experience Transformation,
Digital Engineering, LTIMindtree

Mahesh Esthuri
CTO,
Cloud & Infrastructure Services, LTIMindtree

Pradeep Mishra
CTO,
Banking & Financial Services, LTIMindtree

Prasanna S.
CTO, Consumer,
Technology & Utilities Industry, LTIMindtree

Priti Saini
Associate Director,
Digital Engineering, LTIMindtree

the late Shivaramakrishnan I.
Technology Partner,
Global Technology Office, LTIMindtree

Srinivasa Kattuboina
CTO,
Data & Analytics, LTIMindtree

Suresh Krishnapai
Senior Director,
Data Engineering, LTIMindtree

Sushil Ajgoankar
Senior Principal,
Enterprise Architecture Group, LTIMindtree

Tarun Gupta
CTO,
Emerging Markets, LTIMindtree

Scouts

Chitrang Negi
Senior Trend Analyst,
Global Technology Office, LTIMindtree

Namrata Sharma
Senior Trend Analyst,
Global Technology Office, LTIMindtree

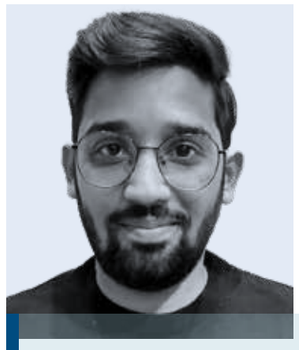
Parag Mhaiske
Senior Trend Analyst,
Global Technology Office, LTIMindtree

Payal Jain
Senior Trend Analyst,
Global Technology Office, LTIMindtree

Sonal Nehe
Foresight Manager,
Global Technology Office, LTIMindtree

Swapnil Chaudhari
Foresight Manager,
Global Technology Office, LTIMindtree

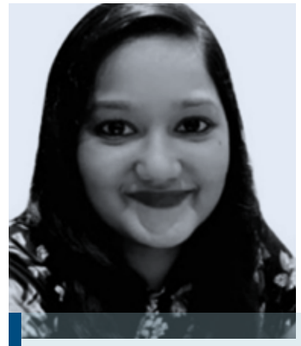
Tanuja Dutta
Foresight Manager,
Global Technology Office, LTIMindtree



Hakimuddin B.
Technical Writer,
Global Technology Office, LTIMindtree

Marketing Team

Divya Cinto
Associate Director,
Global Technology Office, LTIMindtree



Kalpita Surve
Senior Analyst,
Global Technology Office, LTIMindtree

Parmesh Dagar
Business Analyst,
Global Technology Office, LTIMindtree

Tanisha Gupta
Senior Consultant,
Global Technology Office, LTIMindtree

Glossary

ALIS	Autonomic Logistics Information System
AML	Anti-Money Laundering
API	Application Programing Interface
AR	Augmented Reality
AdSS	Advanced Swarm Systems
BFS	Banking and Financial Services
BTC	Bitcoin
CCaaS	Contact Center-as-a-Service
CCPA	California Consumer Privacy Act
CKKS	Cheon, Kim, Kim and Song
CLS	Cybersecurity Labeling Scheme
CPaaS	Communications Platform-as-a-Service
CRM	Customer Relationship Management
CRO	Clinical Research Organization
DARPA	Defense Advanced Research Projects Agency
DLT	Distributed Ledger Technology
DOT	Digital Onboarding Toolkit
EDSP	Exchange Delivery Settlement Price
EHR	Electronic Health Records
eKYC	electronic-Know-Your-Customer
ERP	Enterprise Resource Planning
ETH	Ethereum
EV	Electric Vehicle
FIDO	Fast IDentity Online (FIDO Alliance)
GDPR	General Data Protection Regulation
GPS	Global Positioning System
HCI	Hyperconverged Infrastructure
HEaaN	Homomorphic Encryption for arithmetic of approximate Numbers
HIPAA	Health Insurance Portability and Accountability Act
HITECH	Health Information Technology for Economic and Clinical Health
HMI	Human Machine Interface
IoB	Internet of Behavior
IoT	Internet of Things
IP	Intellectual Property
ISV	Independent Software Vendors
JPO	Joint Program Office
JWO	Just Walk Out
Lidar	Light Detection and Ranging
MFA	Multi-Factor Authentication
MLOps	Machine Learning OperationsMixed Reality
MR	Mixed Reality
NAND	NOT-AND
NFT	Non-Fungible Tokens
NIST	National Institute of Standards and Technology

Glossary

NLP	Natural Language Processing
OBK	ODIN Base Kit
ODIN	Operational Data Integrated Network
OFFSET	OFFensive Swarm-Enabled Tactics
OT	Operational Technology
OTT	Over-The-Top
PBCs	Packeged Business Capabilities
PEC	Privacy-Enhancing Computation
PETs	Privacy-Enhancing Technologies
QKD	Quantum Key Distribution
Qubits	Quantum Bits
RFID	Radio Frequency Identification
RPA	Robotic Process Automation
SCADA	Supervisory Control and Data Acquisition
SOC	Security Operations Center
SoC	System on a Chip
TEE	Trusted Execution Environment
TX	Total Experience
UAV	Unmanned Aerial Vehicle
USD	United States Dollar
USDT	United States Department of the Treasury
UX	User Experience
Vehicle OBD	Vehicle On-Board Diagnostics
VoIP	Voice over Internet Protocol
VR	Virtual Reality
XR	Extended Reality
ZKP	Zero-Knowledge Proofs

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THANK YOU

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info@ltimindtree.com

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