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How Connected Devices Will Remake IoT Systems

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When smart home rivals Apple, Amazon, Google, and IKEA agreed to collaborate on IoT technology, their decision signaled a structural change in market sentiment. In settling on the Matter protocol, they elevated a common interest in connecting multi-vendor smart home devices above proprietary and walled-garden strategies. A similar dynamic is playing out in the enterprise and industrial IoT sectors. Here, digital twins and predictive analytics are the key technology blocks around which consensus is forming. In both cases, the flow of IoT data from IoT devices and IoT platforms is fundamental.

While connected devices are critical sources for IoT data, their full value will come to the fore in interoperable IoT systems. Initially, interoperability applies to the ability to mix and match devices from multiple vendors, as in the case of the Matter protocol. In time, interoperability will apply to the sharing of data across operational and organizational boundaries. This is how the impact of relatively simple IoT devices will have far-reaching, ripple effects throughout the wider economy.

IoT systems, comprising multi-vendor devices, edge gateways, platforms, and business applications, will require greater intelligence in IoT devices. There will also be a greater premium on systems engineering to capitalize on the coming generations of zero-energy sensors as well as new forms of data from joint communications and sensing in 6G systems.

Smart Home Industry Alignment

Roughly a decade ago, entrepreneurs and corporations turned their attention to the smart home market. Frustrated by water damage from a leak in his unoccupied house, one entrepreneur prototyped a monitoring system before launching a Kickstarter campaign to raise funds for the SmartThings startup. Following a $3million seed funding round, SmartThings launched a suite of home monitoring products and then Samsung acquired it in 2014. Around the same time, Deutsche Telekom launched its QIVICON smart home platform business unit, gathering an alliance of home equipment providers, in areas such as comfort, energy, and security. Its aim was to connect and combine

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controllable devices made by different manufacturers.

Over time, firms such as Amazon, Apple, and Google made niche entries into the smart home market, focusing on voice-activated control and programmable commands. None of these initiatives fully energized the market. The reason is that even though consumers had the choice of a growing range of home IoT devices, they remained constrained by single-provider systems. This also meant that they had to deal with the added complexity of managing multiple sub-systems to achieve a full smart home experience.

Responding to these impediments led rival providers to align behind the Matter protocol, a means of connecting home IoT devices regardless of manufacturer. This was an industry breakthrough. It aligned technology rivals while engaging organizations such as IKEA, which is associated more with furniture and household fixtures than IoT and communications technology. IKEA's involvement and industry scale highlights the power of market demand to drive supply-side industry change.

Industrial IoT is Also Coming of Age

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Market demand is beginning to exert a similar effect in the industrial sector now that IoT systems are commonplace in industrial scenarios. The change happened quickly, driven by the COVID pandemic and supply chain vulnerabilities. Business leaders are more receptive to IoT solutions now that they experience operational insights and better decision making thanks to easier access to the real-time data that IoT sensors and connected machines provide.

These developments are triggering new waves of innovation and value propositions. Artificial intelligence helps with decision-making; and machine learning is useful for pattern recognition. Together, they are making condition-monitoring and predictive maintenance applications much more automated and widespread. These techniques belong to the family of Digital Twin systems. Here, IoT data is fundamental to creating real-time, digital representations of machines and networks of interrelated devices. Among other possibilities, there are applications in transport networks and waste-handling systems for smart cities. There is more to come from the innovative uses of extended reality (XR) headsets. These allow technicians to interact and experience machinery repair procedures. Headsets and haptic sensors are other examples of IoT device innovations that are also fueling interest in the industrial metaverse.

As with the consumer and smart home market, solution providers are coming to terms with the need for interoperability. This has two dimensions. The first involves the ability to mix and match equipment and sensors from different suppliers. Following years of intense competition, for example, rival camps agreed to collaborate in the low-powered wide-area IoT device market. Specifically, Actility (a LoRaWAN service provider), and UnaBiz (a SIGFOX technology provider), agreed to integrate their platforms and ecosystems, unifying their low-power wide-area networking (LPWAN) solutions.

The second dimension applies to the data that connected machines and sensors provide. Better decisions and greater value can be obtained when data is shared across departmental and organizational boundaries. For example, tracking the quality of perishable food depends on sharing data about storage conditions for each intermediary in the delivery chain. The ability of supply chain partners to use a common provenance tracking language is another form of interoperability.

As more business-critical decisions are automated in the future, industrial users will demand greater transparency and information from systems that combine IoT and AI capabilities. For example, a plant manager is unlikely to halt a production line without some insight into the reasoning of an automated condition-monitoring system. Transparency and confidence in the reasoning process relies on smarter IoT devices and sensors. That involves providing contextual data alongside measurement data. The former helps users to gauge the reliability of IoT data points.

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Implications of IoT Device Innovation

Future growth in IoT devices will be driven by constrained devices. These are small form-factor, low-processing power, and low energy-consuming devices that can remain operationally active for many years. Researchers are already exploring wireless sensors that can be embedded in walls, bridges, and other structures at the point of construction. A combination of long battery life and reliance on alternative energy sources feature on the technology roadmap for such devices. Some will rely on harvesting energy from radio frequency sources. Others will include energy-optimizing intelligence so that IoT devices can remain dormant until they need to send or receive data.

Once IoT devices are treated as part of a system, designers will standardize systems engineering techniques to optimize the data payload. A practical example is where the IoT system is designed so that the contextual data that accompanies sensor readings need only be transmitted when changes occur. Sending less data will economize on a device's energy use and operational longevity.

The cellular industry's 5G and 6G roadmaps anticipate significant growth for IoT systems and solutions. In industry parlance, there is a gradual shift from enhanced mobile broadband (eMBB) associated with high-bandwidth consumer applications, to massive machine-type communications (mMTC) or the IoT. In addition to fueling industry growth, 6G promises to deliver new types of IoT devices, combining communications and sensing capabilities. This is where radio waves are used for communication and also map a device's surroundings spatially. This "smarter" capability will be useful for context sensing, orientation, and positioning, enhancing the value of IoT devices.

Semantic Interoperability Makes Devices Smarter

Inevitably, IoT devices will need to become smarter to maximize their in-service lives and enhanced sensing capabilities. This will involve another step-change in IoT device and system technologies. Specifically, IoT devices need an interoperable language to voice their full capabilities. This becomes possible by adding semantic interoperability capabilities to sensors design and communications.

These new capabilities combine standardized data models and common service functions that allow system developers to discover, query, and update IoT devices dynamically. An example of this is the Smart Applications REFerence (SAREF) ontology. Developed in close consultation with industry, SAREF provides a shared model of consensus to enable semantic interoperability for smart appliances. SAREF makes it possible for devices from multiple vendors to communicate with one another. The first three SAREF ontologies included variants for the energy, environment, and buildings sectors. Subsequent specifications dealt with smart city, industry and manufacturing, and smart agriculture and food chain domains. SAREF standards are designed to run on top of the oneM2M system of technical standards, which provide the communication and interworking framework for sharing data among IoT devices, platforms, and applications.

As users gain experience with operational IoT systems, their requirements are likely to incentivize vendors to align their solutions through standardization. As the cellular communications industry has proven, this is the pathway to massive scale. A future involving billions of connected IoT devices represents the tip of the iceberg. Its unseen mass represents the infrastructure necessary to support connectivity, data communications, semantic interoperability, and decision-making transparency. Standardization makes it easier for everything to work together. The IoT device revolution will occur as devices become smarter so that any device from any vendor can be discovered and used by any application.

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