The Global Language of Business

GS1 and the Internet of Things

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Executive Summary

The purpose of this paper is to develop a common understanding of the Internet of Things and to explore the opportunities offered within this fast growing area, all from the perspective of GS1.

The Internet of Things (IoT) is the concept of many objects, smart devices, machines, consumers, patients and services being increasingly able to be connected to solve problems in new and more effective ways. The vision behind the concept is that increased connectivity will facilitate automation, visibility and access to services. The IoT promises to enable commercial companies and governmental organisations to increase their ability to tailor products and services to individual needs and to ensure they are delivered accurately and effectively.

The IoT is not any single, specific new technology. It is a framework for integrating digital technologies associated with identification, sensing and data management. IoT applied to manufacturing opens new opportunities for GS1, as illustrated by the initiatives that surrounds new business strategies such as Industry 4.0, also known as Smart Manufacturing, Digital Industry or Digital Manufacturing.

GS1's "Global Language of Business" connects the physical and digital worlds, laying the foundation for IoT. Unique identification of objects, assets, locations, etc. (things) and automatic data capture, powered by GS1 barcodes and EPC/RFID, enable interoperability and are key requirements for IoT.

Seamless, trusted sharing of "big data" is enabled by GS1 standards. IoT is driving increased connectivity of "things" – which leads to massive data collection. Data quality is more important than ever and GS1 standards provide the foundation for accurate, sharable, searchable and linkable data, starting with standardised attributes.

It is recommended that GS1 develop messaging to help users understand that GS1 identifiers are a foundational requirement for successful IoT applications and the associated GS1 "share" technologies (including EPCIS and GDSN) enable IoT capabilities. These messaging campaigns should be developed for both sector-specific and more general audiences. In addition, GS1 should consider proactively enriching its data capture, data discovery and data sharing standards portfolio. This will enable user companies to invest confidently in IoT applications making use of diverse technologies.

1 Introduction

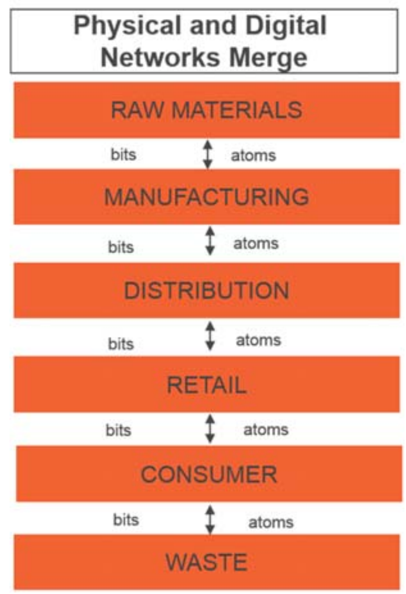
The purpose of this paper is to explore the opportunities offered by the fast growing Internet of Things from a GS1 perspective. After an attempt to define what IoT means and some background information the paper provides a high-level analysis showing how the GS1 system of standards and services fits the typical IoT components. Possible use cases in GS1 core sectors are described. Finally opportunities to extend the GS1 standards and services are discussed.

This paper is intentionally short. It includes references to relevant IoT material including reports from analysts, standard bodies, major solution providers and end users.

2 The Internet of Things

2.1 Roots

The explosion of the commercial internet in the mid-1990s paved the way for the Industrial Internet of the future. In 1998, Sanjay Sarma (MIT) extended the idea of using RFID tags on objects for track and trace purposes. To make it feasible for businesses to use RFID tags in the management of their supply chains, the price of the RFID tag had to be reduced, significantly. Sarma suggested RFID tags contain only a reference number (electronic product code) rather than actual data about the object. It was against the conventional wisdom. At the time, RFID tags were used and designed to contain data about the object or product. By eliminating the need for data storage on the tag, the cost of the RFID tags were reduced. In 1999, Sarma along with colleagues David Brock and Sunny Siu co-founded the Auto-ID Center to transform this vision made possible by the "emerging" medium and the platform of the internet. Sarma, Brock and Siu were later joined by Kevin Ashton who was loaned to the Auto-ID Center from Procter & Gamble. Ashton coined the term Internet of Things which envisioned things connected to object-specific data on the internet which could be accessed using the unique EPC on the tag attached to the object. Partnerships were established with the University of Cambridge in the UK, the University of Adelaide in Australia, Keio University in Japan, the University of St. Gallen in Switzerland, Fudan University in China and KAIST in Korea. The Auto-ID Center developed the EPC and other technical concepts and standards prevalent today in the global RFID industry. The Auto-ID Center expanded to a global network of Auto-ID Labs in 2003, licensing its research results to the then newly born EPCglobal® (now fully integrated into GS1) for commercialisation and standardisation.



2.2 IoT is a vision, not a technology

The Internet of Things is rapidly becoming a reality, driven by the convergence of:

- Everyday use of digital connectivity by industry and consumers, leading to a natural expectation that all things will be "connected"
- The upwards trend in capability and the downwards trend in cost of microcontroller and communications technologies
- The proliferation of cloud-based data gathering, processing and dissemination platforms

The effects of this are transformational for the implementation of systems, devices and technologies across the full spectrum of application spaces – consumer/domestic, commercial, industrial, agricultural, medical, transportation and so on.

There is no universally agreed IoT definition. Many bodies have painfully designed their own. This is because IoT is a concept rather than a specific technology and different organisations tend to define it from their perspective.

Besides the lack of an agreed universal definition it should be noted that concepts generally included in the Internet of Things vision relate strongly to visions under other names, e.g. Web of Things, Web of Goods, Internet of Everything or Cloud of Things. Other concepts including Cyber Physical Systems (CPS), Industry 4.0, Made in China 2025, and Machine to Machine Communications (M2M) are closely related to IoT and can be considered as part of or complementary to the IoT.

IoT is founded on the digitalisation of the properties of things, the availability of electronic connectors on things and the ubiquitous internet communication infrastructure. The mega trend of the IoT of merging the physical and digital worlds also affects consumers and their behaviour. Smart phones are ubiquitously available and act as the medium for consumers to connect the physical and digital worlds. This brings the IoT into a personal context and empowers the consumer to leverage its benefits. What results is a shift from traditional “big data” thinking where companies own all the data to “consumer big data” where the consumer is able to establish and drive a dialogue with his peers, social networks, brands, and retailers.

2.3 The scope of IoT is wide

Source: Beecham Research, *M2M/IoT sector map*, 2013.

Graphic: Deloitte University Press | DUPress.com

IoT is a trend that concerns all sectors of trade and industry. This includes key applications in logistics and warehousing where the movement of cartons, crates, pallets and containers will be tracked with greater accuracy, thus providing better visibility, predictability and efficiency. The impact of IoT is progressive but it has the potential to radically change the way companies operate.

3 Standards for IoT

3.1 Standardisation initiatives

A critical factor in enabling the IoT will be the agreements on what standards to use for identifying things, for capturing data and for sharing information relevant to the IoT applications.

The Alliance for Internet of Things Innovation (*www.aioti.eu*) aims to create a dynamic European IoT ecosystem to unleash the potentials of the IoT. It identified the standard development organisations, industry alliances and open source software initiatives that contribute to the standards required for IoT.

Many standards bodies have implemented plans to develop standards for IoT. Because IoT does by its own nature relate to multiple areas of applications, many existing and forthcoming standards can claim to address IoT requirements. For example, standards for bar codes, RFID, network and Internet technologies are all part of the IoT standardisation landscape.

GS1 enjoys partnerships with several bodies in the IoT context, including:

- AIOTI, the European Alliance for Internet of Things Innovation
- IIC, the Industrial Internet Consortium
- ISO/IEC JTC 1, Working Group 10 on the Internet of Things
- ITU-T, International Telecommunications Union Joint Coordination Activity on Internet of Things and Smart Cities and Communities (JCA-IoT and SC&C)
- W3C, the World Wide Web consortium and their Web of Things interest group

GS1 will continue screening the IoT standardisation landscape and liaising with these entities and others as deemed appropriate.

3.2 IoT reference architecture

Several bodies attempt to describe reference architectures for IoT. For example, IoT-A (*http://www.iot-a.eu/public*) was a major research project funded by the European Commission to develop such an architecture. In their vision, various IoT platforms will emerge and be designed to meet the needs of specific sectors and user communities. They would be based on the same architecture reference model. The roots of the IoT-A tree are spanning across a selected set of communication protocols and device technologies while on the other hand the flowers/leaves of the tree represents the whole set of IoT applications that can be built from the sap (information/knowledge) coming from the roots. The trunk of the tree represents the Architectural Reference Model, the set of models, guidelines, views, perspectives, and design choices that can be used for building fully interoperable concrete domain-specific IoT architectures.

IoT is all about integrating multiple disciplines, e.g. sensors, RFID, networks, cloud, security, information technology, etc. in an interoperable manner. These different technologies are largely standardised but have been considered separately. A reference architecture is an essential foundation to enable integrating the diverse technologies into IoT applications.

Initiatives to develop an IoT reference architecture have been taken by several bodies:

- The Industrial Internet Reference Architecture from the Industrial Internet Consortium, *http://www.iiconsortium.org/IIRA.htm*
- The P2413 Standard for an Architectural Framework for the Internet of Things (IoT) from the IEEE, *https://standards.ieee.org/develop/project/2413.html*
- The Internet of Things Reference Architecture (ISO/IEC 30141) under development by the ISO/IEC JTC1 working group 10 on Internet of Things, *http://iot-week.eu/wp-content/uploads/2015/06/07-JTC-1-WG-10-Introduction.pdf*
- ISO/IEC WG7, ISO/IEC 29182 Information technology -- Sensor networks: Sensor Network Reference Architecture, *https://en.wikipedia.org/wiki/ISO/IEC_JTC_1/WG_7*

The integration of multiple technologies in IoT applications requires a high-level of interoperability between the various components. This is a critical factor to enable IoT applications to develop and to proliferate. The stumbling blocks will not be the lack of standards but at the contrary the fact that too many standards are available, leading to difficult choices to be made when designing IoT applications. These difficulties may often be exacerbated by the defensive attitude of solution providers striving to protect their market and thus not necessarily motivated to adopt open standards and to pursue fully interoperable solutions.

It is thus important that end users contemplating IoT applications include the need for open standards and interoperability in their list of requirements.

3.3 The GS1 system of standards and services is a key enabler of IoT

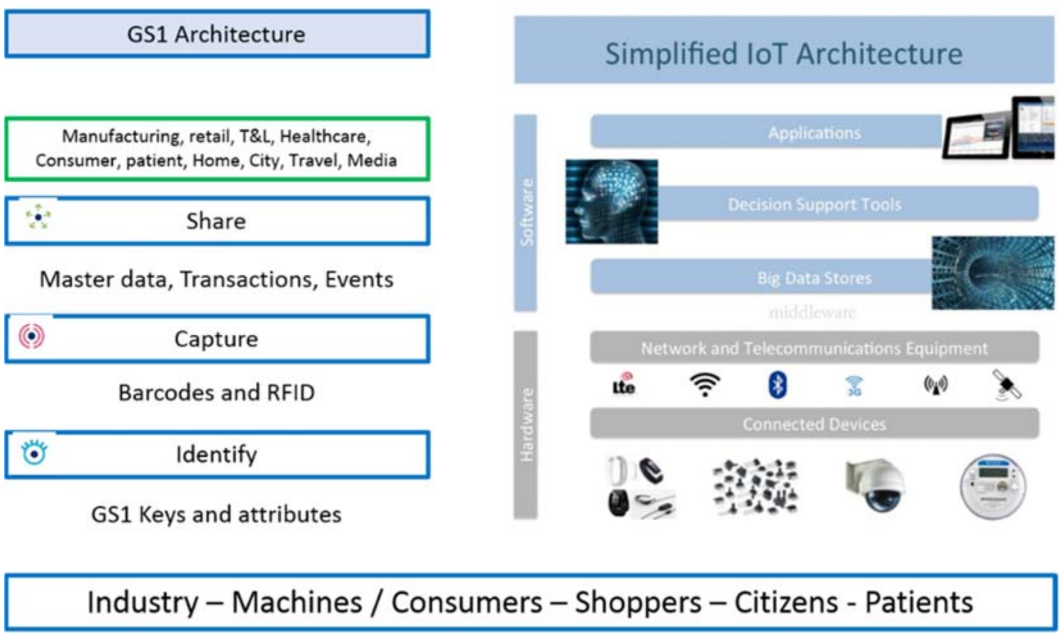
GS1 identification standards provide the means to identify real-world entities so that they may be the subject of electronic information that is stored and/or communicated by end users. The GS1 identification standards include unique identifiers (called GS1 identification keys), which may be used by an information system to refer unambiguously to a real-world entity such as a trade item, logistics unit, physical location, document, service relationship or other entity.

GS1 standards for data capture provide the means to automatically capture data that is carried directly on physical objects, bridging the world of physical things and the world of electronic information. The GS1 data capture standards include:

- Definitions of barcode and radio-frequency identification (RFID) data carriers, which allow GS1 identification keys and supplementary data to be affixed directly to a physical object.
- Standards that specify consistent interfaces to readers, printers, and other hardware and software components that connect the data carriers to business applications.

GS1 standards for data exchange provide the means to share information, both between trading partners and internally, providing the foundation for electronic business transactions, electronic visibility of the physical and digital world, and other information applications. GS1 standards for information sharing are:

- Definitions of master data, business transaction data and physical event data.
- Tools for optimising online product search
- Communication standards for sharing this data between applications and trading partners
- Discovery standards that help locate where relevant data resides across a supply chain and
- Trust standards that help establish the conditions for sharing data in a secure way.



The foundation layer to IoT is the Connected Devices. These devices include barcode, RFID readers and sensors that act as interfaces between uniquely identified objects and the next layers of the architecture where data are transferred, stored and analysed. The triggers are on the one hand the machines executing tasks in an industrial IoT context and on the other hand human beings seeking experiences or efficient ways to do things.

The Big Data Stores are the next important layer of the architecture. The advent of affordable big data solutions means that the large amounts of data collected can be captured, stored, analysed, curated, searched, shared, much beyond the capability of traditional relational database systems.

The next layer relates to Decision Support Tools. Without automation the sheer quantity of data is unmanageable and largely unusable.

The Application layer is where the business functionality lives.

This basic comparison between the GS1 architecture and the simplified IoT architecture shows that the GS1 standards meet the needs for IoT applications.

3.4 Identification is key

The architecture of any IoT implementation will need to make sure that any object can be seamlessly identified across industries and domains, and that data can be exchanged in an interoperable, unambiguous, and scalable manner.

Different identifiers are needed for different purposes. Broadly speaking one can distinguish two main categories of identification requirements:

1) Object Identifiers, which are used for uniquely and persistently identifying physical and virtual objects. The GS1 identification keys meet this requirement perfectly.

2) Communication identifiers, which are used to uniquely identify devices in the scope of communications with other devices, including internet-based communications. Typical examples include IPv4 and IPv6 IP addresses.

GS1 can be used as primary identifier of an object and associated with data captured from sensors. For example event data related to returnable assets such as pallets or crates identified with GS1 can be captured in EPCIS together with sensor data such as temperature, shock or humidity relative to the asset at a given moment in time. IPv4 or IPv6 will be an enabler for the technical communication part of that process.

4 IoT challenges

4.1 Security issues of IoT

The Internet of Things is on the rise and the decisive change accompanying the IoT will be its ubiquity: networked devices are everywhere. Like any technological progress, this development offers social and economic opportunities, but at the same time it also harbours risks.

In the IoT, every networked device is currently a potential target for hackers. Every day, there are reports of IoT-devices being hacked, ranging from control being taken over a vehicle up to interference with the functioning of an anaesthesia device. In the majority of cases, it is at weak points in the software that hackers manage to gain unauthorised access.

No user of a networked device – either business or consumer – can be absolutely sure that the device only features those functions and only executes those data flows that have been specified by the persons or bodies authorized. Thus, for devices in the IoT, it is not possible to trace the data flows and functions actually carried out.

Standards and regulations to enforce and monitor their implementation will be required to strengthen the trust of citizens in their networked day-to-day and commercial life. These need to relate to all sectors and cover the entire networked architecture or value chain.

4.2 Privacy issues of IoT

Any efforts to address privacy concerns should be technology neutral and should only focus on the principles for data use and in what context they should be applied. Government should not focus on the underlying devices or technology enabling those devices.

IoT technologies transcend political boundaries and will only deliver their true potential if policymakers are able to engage with all relevant stakeholders to identify a global framework of principles that can address societal expectations. International cooperation efforts offer convincing examples of how such principles could be developed. Established international platforms for regulatory cooperation would provide an ideal means to develop a truly global approach to the IoT and lead international coordination where new standards are needed.

New regulation inevitably trails innovation and barely supports current business models. A principal based approach encourages innovation by allowing for a flexible response and accountability. GS1 has experience pulling all stakeholders together to develop principal based approaches. Examples include our work to develop global privacy guidelines for Electronic Product Code (EPC) RFID applications and a free Privacy Impact Assessment online tool. GS1 led the stakeholder group that developed a PIA tool that was endorsed by the European Union member states' privacy commissioners, the Article 29 Working Party.

5 IoT use cases

The following chart describes summary examples of IoT applications in the core sectors that GS1 is working with. The common thread in the examples is that they make use of well-established GS1 standards. The "IoT" qualification comes from the fact the applications take advantage of a combination of multiple technologies in integrated original applications.

Retail and Consumer Goods

With IoT products can become smart, changing the relationship between the industry and consumers. Retailers can monitor consumers' behaviour within stores, enabling real-time interaction with them both inside and outside the store. This can improve the retailer's understanding of how they use the environment and what they purchase. It can feed into customer intelligence systems, which can tailor marketing messages, coupons or special offers targeted at segmented groups of consumers or even individuals.

The IoT will be a key enabler for omni-channel retail. Upstream supply chains and downstream logistics can be synchronised using live data from IoT devices embedded in products, factories, stores, warehouses and vehicles to help companies make and keep in-demand products stocked when consumer interest is high. Retailers can offer consumers shorter delivery times, narrower delivery windows, and multiple choices for delivery options.

Healthcare

IoT provides the opportunity to bring to health care unprecedented levels of data generated by patients, making these data an increasingly critical component of decision making and delivery with significant potential to improve outcomes, lower costs, increase access to care, and improve the patient experience. Three areas in particular offer great opportunities:

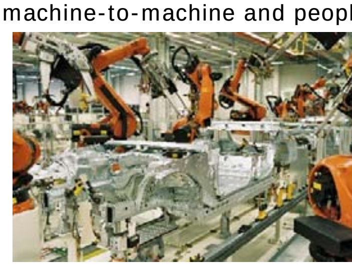
- Short-term care planning: Event-specific data for a finite time period to customise care;
- Chronic-disease management and home care: Continuous data streams to optimally manage narrow sets of known health issues;
- Population-based evidence creation: High volumes of data to better understand how certain determinants of health affect patient populations and inform treatment guidelines.

Transport & Logistics

IoT promises far-reaching payoffs for logistics operators and their business customers and end consumers. These benefits extend across the entire logistics value chain, including warehousing operations, freight transportation, and last-mile delivery. IoT enables the monitoring of the status of assets, parcels, and people in real time throughout the value chain. It can support automation of business processes to eliminate manual interventions, improve quality and predictability, and lower costs. It can optimize how people, systems, and assets work together, and coordinate their activities. And ultimately, analytics can be applied to the entire value chain to identify wider improvement opportunities and best practices.

Technical industries

IoT as part of Industry 4.0, is driving business process innovation, making use of CPS (cyber-physical systems). CPS enables communication, data infrastructure such as Internet, with machines, machine-to-machine and people alike, based on simple questions such as "Who are you?", "Where are you?", "What are your contents?" leading to autonomous decisions and to the control of logistic processes. Interoperability both within and between IoT systems is crucial; without this at least 40% of IoT potential benefits can't be realised. Open standards, such as GS1, is a way to accomplish this (McKinsey). For example, risk/quality management of processes and predictive maintenance of crucial safety-essential components and parts will increase productivity and eventually save human and financials costs.



6 Opportunities for GS1 standards and services

6.1 Identify

GS1 provides solutions for identifying “things” and for connecting the identifiers to the Internet. For example, the Global Trade Item Number (GTIN) is used massively in retail and consumer goods industries to identify products, in healthcare to identify pharmaceuticals and medical devices and in many other industry sectors. In transport and logistics, the Serial Shipping Container Code is increasingly adopted as the universal identifier for parcels that need to be tracked and traced individually from the moment they are shipped until their delivery at the final destination.

The growth of IoT will require persistent identifiers for everything that needs to be accessed and monitored; serialisation of items, objects and assets is an essential part of this strategy. The GS1 identification system is designed in a generic way that makes it suitable for virtually any IoT application that connects things.

6.2 Capture

GS1’s data carrier portfolio comprises seven barcode and two RFID standards. Many other automatic data capture technologies have been developed and deployed, more are emerging, e.g. some 250 barcode specifications; steganography also known as digital watermarking; Near Field Communications (NFC) that is largely available on smart phones; active or semi-active RFID technologies in various frequency bands; sensors; real-time locating systems.

A proactive assessment of data capture technologies will give the opportunity for GS1 to integrate relevant solutions in the standards portfolio.

6.3 Share

The Share layer of the GS1 system comprises three categories: Master data providing descriptive attributes of items; Transaction data consisting of business transactions exchanged between two parties; Visibility event data tracking objects in the supply chain.

A growing set of IoT applications will lead to an increasing demand for accessing and sharing data ubiquitously. GS1 should consider complementary data sharing techniques for the future. For example, additional data bindings (e.g. JSON / JSON-LD in addition to XML) or transport bindings (e.g. HTTP REST, SPARQL) could be developed for EPCIS.

6.4 Services

The ever increasing interconnectivity between objects, people and their environment will require backbone services to provide added-value, e.g.

- What is your ID? Identification schemes management
- Is your ID “legal”? Authentication services
- Who are you? Master data about classes of items, serialized items, legal entities
- Where can I find information about you? Resolution services

GS1 is ideally positioned as a neutral body to provide these core services as part of a future platform to enable its membership to successfully face the fast growing IoT opportunities.

6.5 Education and support

It is recommended that GS1 develop messaging to help users understand that GS1 identifiers are a foundational requirement for successful IoT applications and the associated GS1 “share” technologies (including EPCIS and GDSN) enable IoT capabilities. Pilot projects will be encouraged and supported through the global network of GS1 Member Organisations. A mobile IoT lab could be designed with the contribution of users and solution providers. This could be an opportunity to demonstrate the capability of various IoT technologies and to stimulate the implementation of applications tailored to various business scenarios.

7 Conclusions

1) GS1's "Global Language of Business" connects the physical and digital worlds, laying the foundation for IoT. Unique identification of objects, assets, locations, etc. (things) and automatic data capture, powered by GS1 barcodes and EPC/RFID, enable interoperability and are key requirements for IoT.
2) Seamless, trusted sharing of "big data" is enabled by GS1 standards. IoT is driving increased connectivity of "things" – which leads to massive data collection. Data quality is more important than ever and GS1 standards provide the foundation for accurate, sharable, searchable and linkable data, starting with standardised attributes.

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