White paper

Internet of Things:

Surviving the machine-to-machine protocols jungle

orange™ Business Services

Introduction

MQTT, One M2M, AMQP, MT Connect, OPC-UA... There are so many protocols that are discussed when talking about machine-to-machine (M2M) and the Internet of Things (IoT). Newcomers struggle to gain a clear understanding of them, and even experts find the choice between these protocols challenging.

Looking at these different protocols raises a number of questions: why are there so many available? To which technology layers do they belong? What are their main differences and similarities? Are they all standardized? What are the criteria to use to make the right choice?

This White Paper aims to share a few basic but useful principles to help you find your way.

Summary

01 Why are there so many different protocols?

IoT solutions are provided by a large but fragmented ecosystem of technology companies, ranging from startups to large corporations, and are used in a wide range of verticals. IoT lies at the crossroads of several industries, including Telecommunications, Hardware and Electronic Suppliers, Chipset Manufacturers, Industrial automation and IT.

All of these industries started working on their own solutions several years ago, each with its own considerations and starting points, which led to the large number of protocols on the market. All of these players are now facing the same challenge: offering a simple, cheap, plug-and-play, interoperable and standardized solution to connect different machines and devices to each other and to the cloud. They have approached this issue in two different ways:

- **An horizontal approach,** with a global solution capable of addressing most industries. This approach is mainly taken by Telcos;
- **A vertical approach** with dedicated solutions designed for specific sectors. This approach is mainly supported by vertical leaders (e.g. service providers for Oil and Gas, Manufacturing, etc.). In the case of manufacturing, integrated solutions include OPC-UA, MT Connect and TR-50.

The following diagram illustrates this situation and shows how some of the best-known protocols are positioned.

Specific sectors	Protocols
Telecommunication Industry	OneM2M LTEr12[1]
Hardware and Electronics Industry	IEEE802.16[2]
Vertical Industry	MT Connect OPC-UA TIA TR-50
IT Players	MQTT AMQP
LPWA	LPWA – Low Power Wide Area is a generic term used for new IoT low poser radio networks as LoRa

[1] a 3GPP key release for 4G cellular communications introducing new IoT features
[2] an IEEE standardized technology called wimax and now targeting M2M applications

Diagram 1 - Different M2M and IoT protocols coming from different industries

02 To which technology layers do the protocols belong?

M2M communications involve different technology layers, as shown in the following diagram of the TCP/IP model (it also works with the more complex 7-layer OSI model).

For a more detailed look at the TCP/IP model application layer, we can divide the IoT data protocols in two main sub-categories:

- **Pure applicative protocols** (HTTP, MQTT, AMQP...),
- **And service protocols** (OPC-UA, One M2M...).

Note that service protocols are deployed on top of one or several applicative protocols. For example, OPC-UA works using HTTP or AMQP.

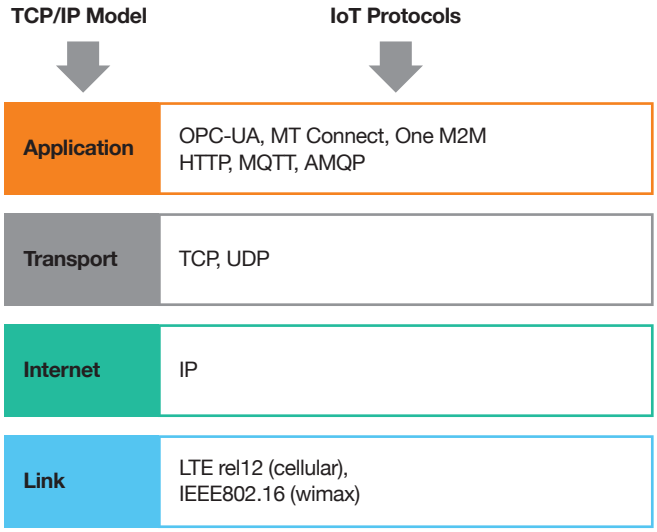

Diagram 2 - Different IoT protocols involved at different technology layers

03 What are the main differences between these protocols?

In this section, we will make three comparisons between different kinds of protocols.

HTTP vs MQTT vs AMQP

All of these protocols are purely applicative protocols operating over the transport layer (TCP/IP).

HTTP (HyperText Transfer Protocol) is a well-known client-server protocol which we use daily while browsing online. HTTP was originally designed to display web pages from an HTTP server (like Apache) to a web browser (like Mozilla). It also enables data sharing between servers, and of course data exchanges between machines in the M2M context.

The main advantage of this protocol is that it is standardized, well-known, and easy-to-use with many of the solutions available (APIs, HTTP servers, HTTP clients, etc.). However, it was not initially designed for M2M communication, leading to sub-optimal performances on tasks like managing small messages or real-time communication between many machines.
MQTT (Message Queue Telemetry Transport) is a publish/subscribe standardized protocol (MQTT v3.1.1). Initially developed by IBM, it is now available in open source. This protocol is well suited to M2M applications that require frequently sharing small messages (thanks to a very low overhead ratio per message). Many MQTT applications and libraries are available.

AMQP (Advanced Message Queuing Protocol) is an open protocol created to share messages between servers. It offers both publish/subscribe and point-to-point modes. AMQP is known for its performance on management of very large volumes of messages. It was initially developed by JP Morgan Bank, with support from a large consortium including Cisco and Microsoft.

All of these protocols can be used for M2M applications and offer enough functions to send and retrieve data to and from servers and machines.

	Strengths	Weaknesses
HTTP	■ Standardized and spread protocol, ■ With HTTPS, security can be adequately ensured	■ Less efficient from a data bandwidth consumption point of view, ■ Less suitable for IoT networks
MQTT	■ Very efficient to manage small, frequently shared messages ■ Publish/subscribe protocol capable of handling one-to-many communications	
AMQP	■ Very efficient to manage small, frequently shared messages ■ Publish/subscribe protocol capable of handling one-to-many communication	

Note that the choice between HTTP, MQTT or AMQP is not always available when using a specific service protocol. For instance, the current implementations of OPC-UA only support HTTP or AMQP.

4.1 One M2M vs OPC-UA

One M2M and OPC-UA are not only data exchanges protocols, but Service Layer Protocols. They also offer a generic architecture, data models and methods, and standardized APIs. Both use lower-layer protocols such as HTTP, HTTPS, MQTT, AMQP.

4.2 One M2M

As detailed by the One M2M consortium, *"the purpose and goal of One M2M is to develop technical specifications which address the need for a common M2M Service Layer that can be readily embedded within various hardware and software, and relied upon to connect the myriad of devices in the field with M2M application servers worldwide"*.

The objective is clearly to offer a standardized cross-sector solution that allows M2M applications and systems to interoperate and collaborate, regardless of their industry. One M2M is relevant in markets where different verticals need to be interconnected. Smart Cities are a perfect example, since many solutions and systems from different verticals and providers (including public transportation, connected cars, and smart buildings) must be interconnected.

4.3 OPC-UA

As defined by the OPC Foundation, *"OPC is the interoperability standard for the secure and reliable exchange of data in the industrial automation space and in other industries. It is platform independent and ensures the seamless flow of information among devices from multiple vendors".*

OPC-UA is widely accepted and deployed in the manufacturing industry. Most of the automation HW & solution providers (like sensors, PTC providers, etc.) offer OPC-UA compliant products, and the protocol allows interoperability between products from different suppliers. It is virtually mandatory for manufacturers to use OPC-UA compliant solutions because the resulting interoperability supports future evolutions of their operating landscape and decreases the total operating cost of the factory.

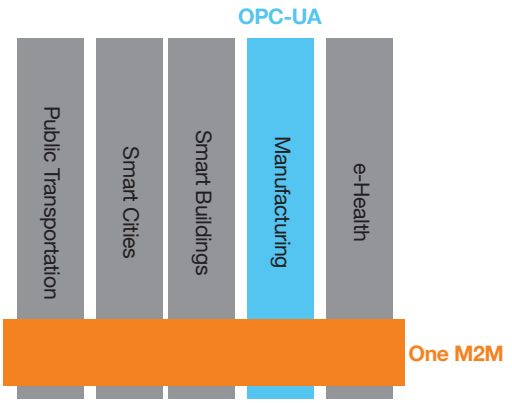

Diagram 3 - One M2M vs OPC-UA: a choice between a mono-sector or cross-sector protocol

The choice between service layer protocols (OPC-UA vs One M2M) seems to be driven by business and strategic decisions (mono-sector activity vs. cross-sector) rather than technical considerations.

4.4 MT Connect vs OPC-UA

MT Connect as presented by the MT Connect Institute *"an open, royalty-free standard that is intended to foster greater interoperability between devices and software applications. By establishing an open and extensible channel of communication for plug-and-play interconnectivity between devices, equipment and systems, MTConnect allows sources to exchange and understand each other's data."*

Conclusion

The reason why multiple protocols exist is due both to the diversity of the technology layers they serve and to the fact that different industries started working on the same issues a few years ago, delivering different solutions.

We are currently witnessing a dual convergence of the protocols: a horizontal convergence (solutions available across different industries) and a vertical convergence (highly specialized solutions for specific sectors). In the case of manufacturing, although competition still exists between MT Connect and OPC-UA, the latter is taking the lead.

Choosing a protocol for an M2M project remains complex. This technology choice should also be business focused, in order to take into consideration all of the functional needs and constraints. This choice will directly impact the economic performance of applications and the sustainability of any digital industrial business case.

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