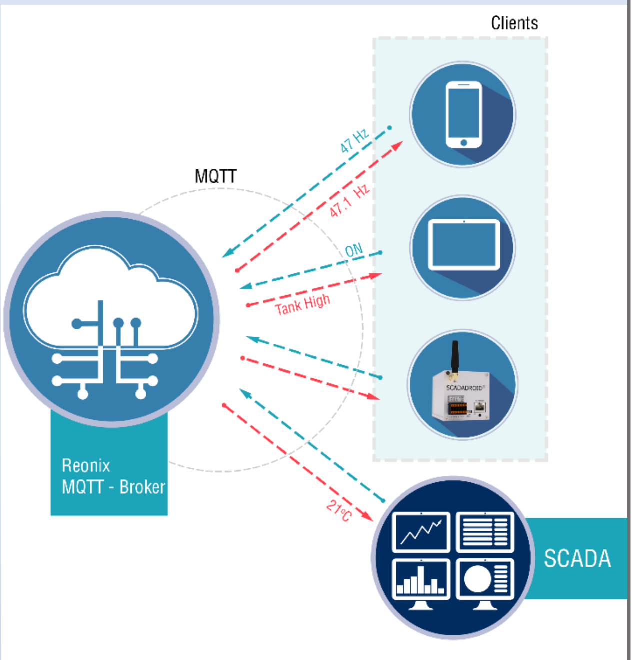

MQTT today can integrate smart sensors for example, with digital and analog I/O, but the challenge for the very near future will entail industry disruptive IIoT technologies converging into an integrated automation process.

MQTT, Industry 4.0, and the Future of Automation

IIot with MQTT

Reonix Automation

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Artificial Intelligence: a virtual neural network, capable of memory, information processing, synthesis, and abstraction

Automation: the general process of using technology to mechanize the most sensitive aspects industrial control, most critical of which include monitoring and contingency control

Bandwidth: capacity for data throughput from a local network to the internet

Big Data: the accumulated sum of analytics gathered by the Internet of Things and information that has been transcribed to the internet

Blockchain: data (mostly currency) generated and verified by cryptography, which takes place over a distributed network on the internet

CoAP: an alternative to MQTT, also tested by experimenters alongside MQTT

Data Packet: a data string enveloped by protocol layers, such as the network layer and the application layer, so packaged for the purpose of routing data to the right client

HMI: Human Machine Interface, an operating system displaying and providing interface capability for the components of the field level, and the control level of the control system

IoT: the network of smart devices emerging as a platform for analytics, control, and device integration e.g. Smart phones, smart outlets, smart appliances, smart thermostats etc.

IIoT: IoT as applied to an industrial setting, including smart sensors, smart control switches, and other such equipment

Industry 4.0: also known as the fourth industrial revolution, whereby robotics, distributed computing, Big Data, and IoT will vastly improve the efficiency and division of labour in primary, secondary, and tertiary industry – in much the same way that steam power first revolutionized production and labour in England during the 19th Century

Industrial Control Systems: the general term for automation components and processes, one that invariably involves field-level plant operations. More general than SCADA

m2m: Machine to Machine Protocol, i.e. the “language” that allows two IoT devices to communicate data to one another

Machine Learning: analysis and processing of analytics, with recommendations for optimizing outputs

MQTT: Message Queue Telemetry Transport, a lightweight telemetry protocol for devices linked to a Message Broker

Message Broker: a distributed computing solution hosting clients and server devices, available as a service operating over the internet

Systems Integration: often involves programming PLCs and routing them to HMI for system control and alarms clearance, but can involve IIoT, SCADA hardware and software setups, and other solutions for automating plant operations

SCADA: Supervisory Control And Data Acquisition, which allows a human operator to act on alarms programmed into a control system, often involving Programmable Logic Controllers, a Supervisory Terminal, and field level sensors, switches, and other instruments

Telemetry: transmission of data from one destination to another

QoS: Quality of Service, the result of latency as it varies by the influence of other factors such as power consumption, data throughput, and signal strength

Agenda

What this whitepaper sets out to answer boils down to the issue of systems integration. PLC programming arrived as a solution to expensive electrical relay systems rewiring. Rather than pulling out copper wires every time a SCADA monitoring setup needed adjusting based on alarms, a programmer could just alter the function code to alarm off new inputs or setpoints. And so MQTT today can integrate smart sensors for example, with digital and analog I/O, but the challenge for the very near future will entail emerging (and industry disruptive) technologies converging into an integrated automation process. What this means is, massive flows of data will be required to make automation still more automated – and thus, that much more effective.

This paper will explore MQTT's role in SCADA hardware and software solutions, a look at some of the data available on MQTT's queuing strategy and its effects on latency depending on packet size, and finally, 5 ways that this protocol can save on the costs associated with data telemetry.

How Remote Monitoring can be Revolutionized by MQTT

To speak to the issue of telemetry like MQTT, it must first be put into context. Why a protocol can revolutionize an industrial application depends on how industry will be

Figure 1: https://readyspace.com/industry-4-0-and-application-virtualization/

conducted, and what tools will be used in the near and far futures – so as to avoid investment in soon-to-be-outdated control systems.

Industry 4.0, a term describing the future of primary, secondary, and even tertiary industrial processes, will heavily rely on leveraging a massive flow of data – between end-users, Industrial & Consumer IoT devices, Intranets, Big Data, and perhaps even Blockchain. This transformation will probably involve Artificial Intelligences (or if not quite that level of machine cognition, at the very least, machine learning), and it will definitely involve machine to machine (m2m) interface and processing.

Machine to machine interface and communication protocols are key to the future of industrial automation, as stringent industrial control system requirements will soon be met by rapidly improving standards in the IoT environment; IoT as applied to industry is now known as IIoT, but we will likely see an integration between the two. Events are the impetus for administrative operators responding to alarm conditions, and for now the actionable response is often left to humans. But soon, IIoT devices will have complex responses to contingencies based on acquired data, and much of SCADA's supervisory level (and beyond to the production and scheduling levels), can be automated for better efficiency. Such a shift in procedure will free up your operational personnel's attention – diverting their hands and eyes from HMI terminals, and towards other areas requiring attention. This means rolling with the momentum of the Industry 4.0 Revolution rather than struggling against it or missing out entirely.

For the time being, operators are content to remain in control at the supervisory level of industrial control systems. What used to be constant supervision of industrial control systems now requires response only when critical events trigger alarms, at least in a

SCADA setting. The role of the human being in this process is now much more meaningful. It makes the operators in charge of event response an executive rather than a sentry, and the automation of datalogging presents the opportunity to ensure that they are not overburdened with Quality Management or Safety Standard documentation as well.

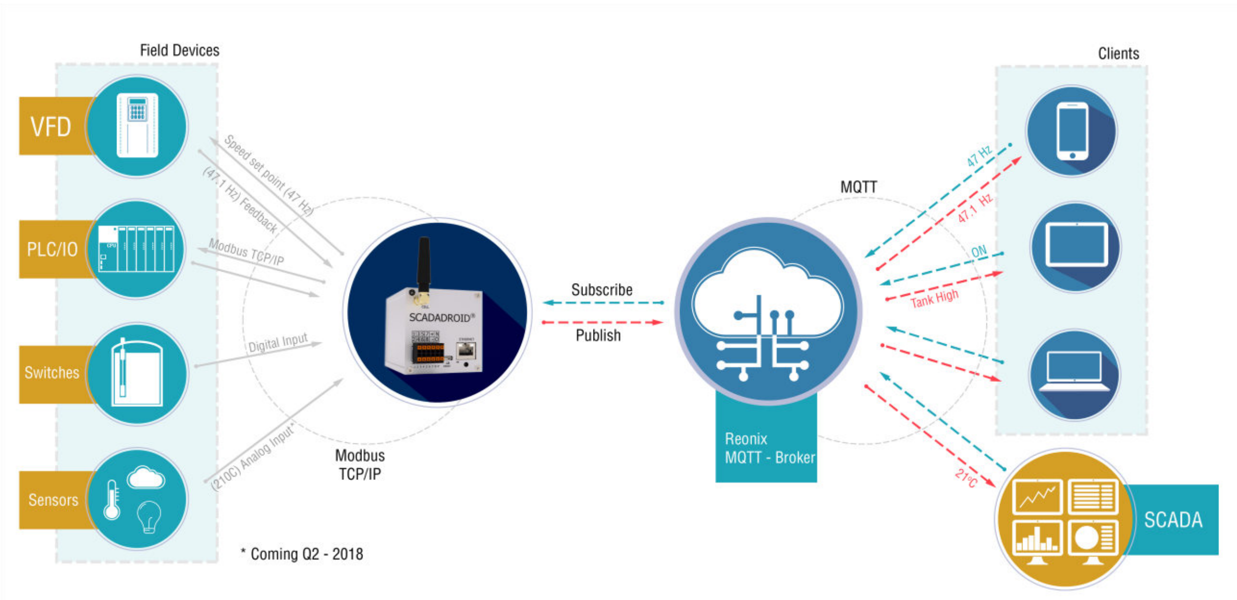

Figure 2: SCADADroid® MQTT

Development of SCADA Hardware and Software

The development of SCADA equipment is varied and few solutions on the market are identical. Multifunctional equipment is a de facto market offering, so products with an initial function in a SCADA setup may often take on complementary functions, rather than having a dedicated function, since fragmenting the required equipment would make clutter for the plant operators. The downside to a wide variation in equipment function is the complexity of the setup, necessitating the consulting services of systems integrators to ensure that equipment from different companies can be utilized, rather than submitting to dependency upon a SCADA equipment sales company to do their customer's purchase planning for them.

But the most exciting benefit of IIoT functionality in a multipurpose device is how it enhances and integrates other digital and physical features into a much broader virtual process. One such IIoT protocol is MQTT, a reliable protocol first developed by IBM. Message Queue Telemetry Transport is a lightweight protocol that can ration the transfer of data packets going over cellular by way of its queuing procedure. Essentially, an MQTT device at a remote site can act as an IIoT Gateway, bridging smart field devices to cloud servers.

Minimal transfer from a remote location to a cloud based broker, is further distributed to the edge of the wired network (if the centralized distributed network on the internet is called a cloud, then server computing localized nearer to the IoT field level and control level devices can be called a 'fog' (i.e. clouds reaching down into a city street), meaning that only essential data is transferred over cellular, and telemetry transports in carefully measured quantities. High priority is fire-and-forget, whereas lower priority data packets will queue for the right network latency, applicable to the purpose of saving on cellular data consumption overall. Lower priority queuing preserves bandwidth by waiting for data bottleneck at the gateway to clear before sending.

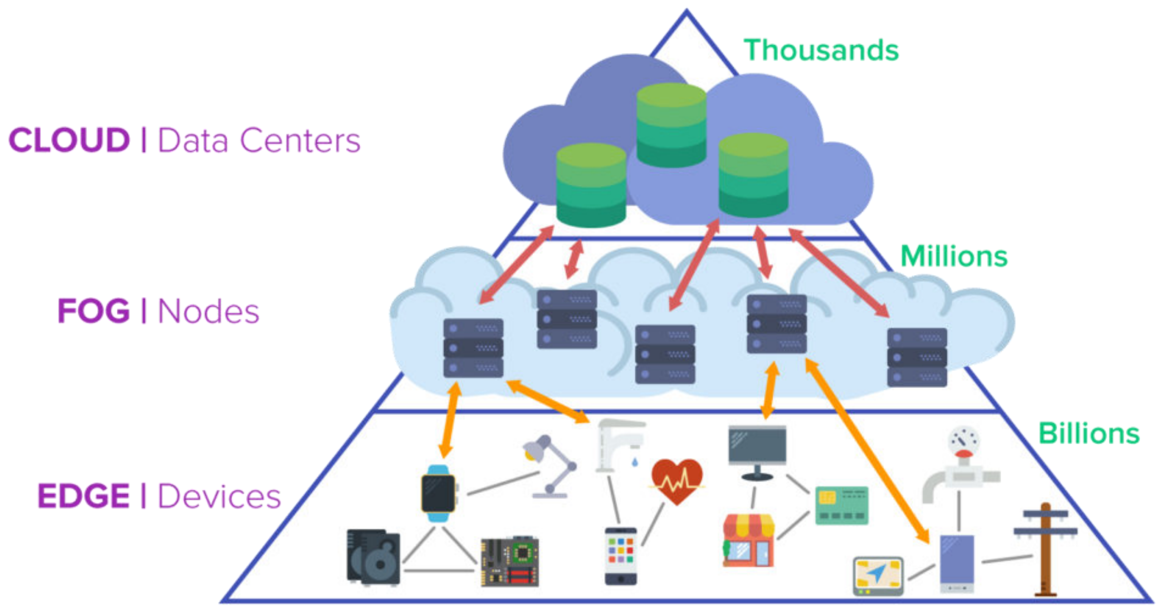

Figure 3: https://www.pubnub.com/blog/moving-the-cloud-to-the-edge-computing/

Testing MQTT Over the Network

In an experiment conducted by Alexander Lagerqvist and Tejas Lakshimarayana, real world usage of MQTT provided interesting insight on the relationship between network latency and quality of service resultant from MQTT configuration. The test was done over a CombiQ network, and alternatively, a simple apartment WiFi setup.

Messages queued at low priority such as QoS 1 (send at least once), and QoS 2 (send once) are fairly consistent in their transmission time of about 140 milliseconds locally, despite increasing data packet sizes – which allows for voluminous flows of data without bottlenecking network bandwidth too severely (Lagerqvist & Lakshminarayana, 2018, p. 63). Messages queued at QoS 0, the fire-and-forget setting, experience little delay provided packet size is within 0.12 KB; beyond this size, latency for 120 Bytes begins ramping up towards 40 milliseconds (Lagerqvist & Lakshminarayana, 2018, p. 63).

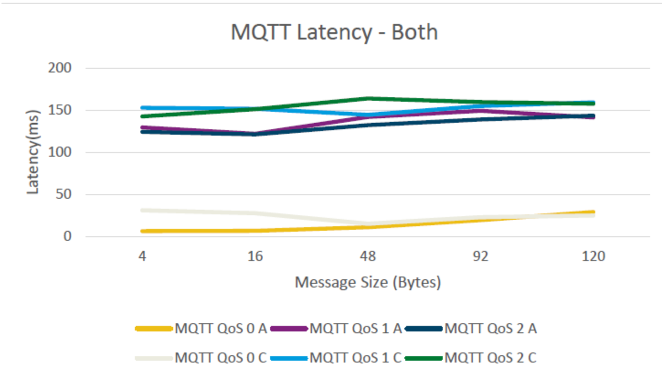

Figure 4: (Lagerqvist & Lakshminarayana, 2018, p. 63)

While the experiment's power consumption question was inconclusive (Lagerqvist & Lakshminarayana, 2018, p. 71), the experimental data on Message Queuing looks promising for a network at which the gateway experiences a bottleneck – such as a crowded IIoT edge network at a remote site.

1. **Queuing**: Communication limited to a small code size allows the m2m client to send published values (data points) collected from the m2m server device (such as a sensor) to the cloud-computing broker, where any access or further data processing can be sent to local area networks unconstrained by data restrictions; the m2m part of the telemetry compresses and rations the packets sent out, whereas the machine to cloud, and machine to human portions of the Pub-Sub (publish and subscribe) telemetry can relay back and forth more freely.

2. **Actionable Messages**: Actionable data sent over MQTT, as with digital or analog I/O for instance, saves enough money to give the operators the choice between using a cell budget to access and reconfigure the setpoints of fieldbus clients remotely, through VPN for instance, or sending personnel to deal with the remote site if remote access fails to resolve the problem.

3. **Telemetry Prioritization**: GPS is a data efficient technology when the positioning results are communicated to a networked device over MQTT. If your remote monitoring is on the move, as with a fleet management application, then it's imperative that positioning data be of the right level of importance, and that it be sent in such a way that keeps cellular data consumption costs low – as there's no doubt that mobile GSM expenses can hurt a company's bottom line, especially where less than critical information must consume more bandwidth to reach the MQTT Broker. MQTT as a protocol makes assessments of the event-data's urgency, and queues events' data for efficient transport.

4. **Alarm Conditions Only**: With a fieldbus setup like Modbus, polling events communicable over MQTT makes SCADA a low-cost proposition. Rather than sending Modbus read-commands over cellular to the supervisory level client, the Modbus control level client can queue alarm condition data and publish events to the MQTT broker. From the broker, the supervisory level (using devices such as personal computers, smartphones, and tablets) can be notified of subscribed-to topics and can publish new setpoints back to the Modbus client via the cloud broker.

5. **Computing on the Edge**: At a remote site IIoT integrated via MQTT, multiple sensors and (or) data processing units can communicate with one another, and if necessary, can be formed into a distributed cloud-like processing network that serves as a local extension of the cloud – in essence, fog computing or edge

computing. A fog will be able to roll down from the cloud to the remote site, and much of the data processing work that would be done in the cloud (distributed processing over the internet) can be done right there at the remote site; rolling the fog down to your remote site would mean that only the most essential data would be published to client devices via MQTT Broker, which in turn would mean that cellular data consumption would be kept to a minimum.

References

Lagerqvist, A., & Lakshminarayana, T. (2018). *IoT Latency and Power Consumption.* Jonkoping: Jonkoping University.

Suggested Reading

Edge Computing – Key Drivers and Benefits for Smart Manufacturing

Can the Industrial IoT Produce Energy Savings in Smart Factories?