Cubicon

Architectural solutions for the Internet of Things

The IoT Market Opportunity for Wireless Network Carriers

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The IoT Market Opportunity

The latest stage of the next great race is on. If we did not hear the starter’s gun in the middle of 2012, then perhaps pronouncements by a number of the planet’s most notable CEOs offered a late start notification. GE’s Jeff Immelt and Cisco’s John Chambers headlined a collection of Fortune 500 tech and industrial enterprise executives claiming that one form of IoT or another would be the future of their company.

And then … they offered very little detail or logic on where, when or how they or anyone else would arrive at that IoT-enabled future.

How could they? The requirements to build out and operate M2M and IoT solutions that truly enable a better future for the planet – and their shareholders too – involve three very complicated questions.

1. What do we want our future to look like and how can IoT deployment enable it?
2. What technologies, tools, methods and processes do we need to deliver on those visions?
3. Which business models can serve as the ‘what’ to stitch together the why (#1) with the how (#2)?

This paper is a primer on an approach to the second question. It is fitting that we start there, for so much of the technology and service supplier community is focused here. So many solution developers and evaluators are focused on technical questions that many are doing far too little by way of participating in the first question.

And the cost to this allocation of resources? Incalculable. Why? For the potential for intelligent, intentional application of IoT solutions is greater by orders of magnitude than anything we have seen with mobile apps, social media, or the enterprise application of big-data framed by double-entry booking ruled corporate accounting. This is an enormous statement, we know, but consider:

1. 90% of mobile application developers lose money. Those who do earn, banked an average of $18,000.00 in 2011. All that time and talent has to show for its effort is … Angry Birds, Temple Run and Evernote. All that time and talent enabling so many people to consume time, not create it. More time wasting entertainment apps than productivity apps by orders of magnitude. Few income producing jobs. Fewer profitable, sustainable companies.

2. Nearly 70% of the Fortune 500 and Inc 500 are decreasing their investment in social media. This is according to a longitudinal study of these companies approaching its tenth year. On the one hand, these companies cannot build a reliable ROI for social media. They know they need to do something, but, they cannot really quantify the benefits. On the other hand, there are other shiny new objects entering their fields of vision – like gamification!

3. For 30 years, the developed, and an increasing portion of the developing world, has been investing trillions to digitize their financial accounts, and increasingly, automate elements of their physical world operations from their now digitized ledgers. Their results have been pretty strong. Corporate profits and elite institutional investors have made vast fortunes during the past 30
The IoT Market Opportunity for Wireless Network Carriers

years. And the hyper-concentration of financial capital has wrought havoc on world markets and communities such that today the gaping income divide is perhaps the greatest threat to the United States and most other free market democracies than any other natural or man-made condition on the planet.

To be fair, mobile, social and big data are creating value. And given workplace obsessions with productivity, we can do so much better than the returns on these investments. The M2M/ IoT opportunity is a once in a generation (or more) chance to do that much better.

To be clear, forecasting the number of devices to be added in IoT and M2M deployments is specious. How many billions of devices? What types and configurations of devices? How will they be connected? What services will they consume? Create?

Tens of billions at least. All manner of configurations optimized for applications and application clusters. Wireless will be the dominant connection method, even for stationary installations. The services they consume and create will be limited only by our imagination – and our infrastructure.

We state that this paper is a primer on a technical approach. That technical approach focuses on the potential benefits for wireless network carriers – specifically the wireless network carriers.

Carriers

We believe that IoT and Machine-to-machine (M2M) technology can revolutionize the way a lot of things get done. But we must address the technical complexity that is IoT and M2M development, deployment and operation. Today, IoT and M2M are simply too costly for serious deployment consideration by too many companies.

Especially if you are a wireless carrier …

![Figure A: M2M = low ARPU?](image)

A number of carriers are engaged, committed even, to being a central part of IoT and M2M rollout. Publicly they are bullish and investing to create value. But privately, they are
The IoT Market Opportunity for Wireless Network Carriers

confronting a harsh reality: The fractional average revenue per user (ARPU) in M2M compared to smartphones is 1 to 3. 1/3. For this reason alone we think M2M/ IoT might be an entirely new business, and not merely an extension of their ongoing operations.

But can carriers realistically sustain profitable growth with their current strategies? Can they securely, reliably, profitably scale IoT/ M2M to a moderate degree – 10 billion nodes during the next 10 years – with their current approaches?

1. Verizon is buying and building niche technology plays in highly fragmented, highly competitive markets. Hughes Telematics acquired for nearly $700 million is a prime example. They are clearly a major player in both OEM and aftermarket vehicle telematics. How will the announcements from auto OEMs at CES about creating new, or opening existing telemetry and telematics platforms of their own impact this investment?

2. AT&T is organically growing industry and application-specific market development teams. How long will that take and what key challenges will they face in highly fragmented, highly competitive M2M/ IoT markets that are exhibiting preference for SME (subject matter expertise) from existing sources of computing, control and communications solutions?

3. Sprint is investing significant resources in defining new business models that attempt to leverage other people’s time, talent and capital. Softbank brings a broad array of technical and operational potential. How much enablement IP will they create, how much can they insert, in complex commercial ecosystems?

Wireless Network Carriers are facing significant challenges at both ‘ends’ of their businesses:

1. They are compelled to invest in network capacity to meet demand; and

2. They must be an active part of enabling new revenue-generating applications and services

Of course, no one wants to play the subsidy game again. Figure B illustrates the point.

Carriers Reality – Current and Positive Continuum

Figure B: Network carriers facing flat revenues
The IoT Market Opportunity for Wireless Network Carriers

Many throughout the IoT and M2M developer community would agree that we are suboptimizing with IoT and M2M potential because we are stacking turtles. Yet we continue with the duct tape and bailing wire to chandelier them. Hey, no stacking …

You see, the challenges associated with simply getting devices connected at reasonable cost, reliability and security levels has carriers focused – almost myopically – on new device adds. For new device adds drive data. And carriers get paid for sending and receiving data.

And that might be the biggest problem for carriers in IoT and M2M. They are still focused on devices and data. They are not focused enough on participating in the financial rewards generated by new applications, service and value creation. Or maybe they are not welcome?

And carriers continue to go through all that pain and effort and risk and arrive … back at the place they started: Commodity bit brokers in M2M and IoT. Not completely, but, you get the point.

And all that potential implied by IoT and M2M evangelists? We have done so little to explore the great value that can be created. We are too busy sorting the technical challenges. And the great ideas that aspire to create authentic value? Too many are locked up or locked out and do not come to light. The high cost of acquisition, deployment and operation, rooted in part in the oversimplified goals of device adds and MB consumption constrain the opportunity in three ways:

1. Keeping total cost to deploy prohibitively high, driving onerous ROI and limiting the ideas that get funded;
2. Missing the point – and the revenue and margin – available in persistent sockets (not throw away devices), low bandwidth consumer short, bursty data transfer models (versus noisy dirge-like bitpipes) – that can enable high value application and service creation; and ultimately;
3. Consuming the time, talent and capital that might think up and fund the what and the how of the future of life, or business, or medicine, or transportation or governance.

As we all know – empirically or intuitively – it is not about the devices or the data. It is about the value that the right data from the right devices can create. And that means context. A context generating architecture that represents semantic relationships to help unattended/ headless devices and things ‘understand’ the information they receive and transmit. And do it in context-sensitive ways that maximize authentic value creation.

A few leading thinkers and practitioners in these markets know this. Slowly, more are coming around to it. It is hard stuff this M2M/ IoT thing. For in its best form, it does not suck us into screens, it frees us from them.

Context. It creates time rather than consume it.

The Cubicon approach highlighted below is all about context.
Cubicon and Context: The ‘Big Idea’

The next generation of software infrastructures will need to support interoperability between many billions - and eventually, trillions - of network-connected devices and Things (nodes). We believe the most effective and efficient way to provide this level of interoperability is through the extensive use of automation, supported by context.

Context is the ability for a node to 'understand' and act on data that is presented to it; data it may never have seen before. **Contextualization is the technical foundation for automating M2M interactions, and 'the big idea' behind Cubicon.**

The communications industry went through a paradigm shift when it replaced telephone operators with switch technologies that automated a process previously done by hand. We are suggesting a similar paradigm shift: replace programmers with a technology that automates the interoperability process, currently done by hand (Figure C). Putting together armies of programmers to hand-encode and manage systems across billions of nodes is both unrealistic and cost-prohibitive.

![Figure C: Automation enables two paradigm shifts in communications](image)

**Cubicon** is the name of a systems language and net-centric computing platform. In the following sections, we will provide an overview of Cubicon’s suite of technologies from a wireless network carrier’s perspective.

**CubeWeb**

To achieve interoperability between nodes, the Cubicon Platform supports an ‘intelligent’ internet layer with machine reasoning capabilities called **CubeWeb**.

CubeWeb provides the following features:

- **Node and cloud interoperability** – In much the same way the Web uses a URI, CubeWeb use a Globally Typed Identifier (GTI). GTIs are represented in integers, for two reasons, 1) to be natural language neutral and 2) they are more efficient to process. GTIs are assigned to all entities, software components and nodes in CubeWeb.

- **Trust** – CubeWeb is intrinsically secure because all software structures and behaviors are composed from a finite number of language element types with well-understood properties.
System-assisted collaboration tools – CubeWeb allows groups to collectively express software. Language elements are recombinant meaning that they support software reuse at all levels of systems scale.

CubeProtocol
Whereas, the Web uses HTTP, CubeWeb uses the CubeProtocol. The protocol collapses the function of the OSI Model’s three highest layers (5-7) into a single, streamlined layer that supports fine-grain communication down to the level of Things that run very simple monitoring/control algorithms. Using the CubeProtocol, Things will be able to communicate over an IEEE 802.15.4 channel; in parallel to legacy Personal Area Network (PAN) channels (Figure D).

Figure D: CubeProtocol spans the three network realms

Devices and things will communicate through a Cubicon PAN Coordinator device. Each PAN Coordinator device is assigned an IPv6 address, and will maintain sub-addresses for all reduced-function Things under its control (Figure E).

Figure E: IoT node forms
The PAN Coordinator:

- Incorporates CDMA/GSM to accommodate devices,
- Incorporates an IEEE 802.15.4 wireless capability to accommodate Things (motes),
- Is assigned an IPv6 address, and will maintain sub-addresses for all reduced-function Things under its control,
- Mirrors monitoring and control algorithms to provide backward compatibility for existing software.

**CubeEngine and CubeMicro**

*CubeEngine* is the proprietary name for Cubicon’s virtual machine. Features include real-time performance, security and a small footprint - ideal for embedding into devices. It uses a contextual model that represents semantic relationships in context. This helps unattended devices ‘understand’ the information they receive.

*CubeMicro* is the part of the CubeEngine that can operate in low-power Things and through low-bandwidth channels. The ability to remotely reconfigure fine-grain software components will aid in the migration from reduced-function Things to advanced-function Things.

**CubeCloud**

*CubeCloud* performs the contextualization function for all data across the CubeWeb, and consists of the Context Registry, Service/Component Exchange, Entity/Community Repositories and Topic Maps.

The Context Registry enables ‘search’ of software components and services on CubeWeb. It supports trust by tying each component and service to a particular community/entity, through the use of GTIs.

The Component Exchange performs the push/pull discovery of components between Community Repositories.

The Service Exchange dynamically performs service negotiations and provides a lucrative opportunity to monetize transactions between producers and consumers.

An Entity Repository maintains identity verification/certifications for CubeWeb users. It manages a user’s session/s with multiple devices and Things under the user’s control.

Each entity (person or institution) maintains a ‘home’ Community Repository. It manages an entity’s software components; maintains component ontology; manages links between language elements during design-time; and produces custom system configurations for the entity’s devices and Things. The Community Repository is responsible for ‘anchoring’ the meaning of concepts between communities: a key function to support interoperability across proprietary clouds and the IoT.

A Topic Map graph is an interface used to control access to an entity’s personal data locker. A user’s devices/Things can securely access and process their private data through this interface. Access can easily be extended to others, and can even be instrumented to collect fees on user-generated content.
The IoT Market Opportunity for Wireless Network Carriers

Exchange Services

An exchange service allows a system to interact with other systems under CubeWeb. They are the equivalent of the following legacy technologies: REST, SOAP, REST, SQL/NoSQL, SPARQL and more. A producer can affix a transaction fee for its use by consumers. Exchange services represent the first six layers of the CubeProtocol, and will operate on top of TCP/IP, (Figure F).

The CubeProtocol provides network monetization mechanisms to directly harvest and distribute new services throughout the Cubicon ecosystem.

*Example:* An entity (service provider) sets a retail price and availability for a particular exchange. A portion of the service revenue would be distributed to the network carrier and the CubeProtocol licensing organization. Both provide ongoing enhancements to the physical network and contribute to CubeProtocol enhancements that will be necessary during the CubeWeb’s build-out.

The following section covers the six types of system exchanges under CubeProtocol. Each was designed to specifically address the *intent* of the legacy exchange technologies.

A **Closure** connects a client system to a server system, via a stateless/stateful exchange. It uses a transactional mechanism that can directly optimize parallel processing for shared memory systems. An *example of a closure-based service would be a person’s current physical location.*

A **Dialogue** connects systems by consensus, adopted by community members (stakeholders). Dialog contexts contain data, shared between devices to establish a common understanding of the content being exchanged between systems. The orchestration schema is used to manage shared data between systems, and can be used to subcontract exchanges with other systems, as well. An *example of a dialogue-based service would be to establish a standard way to complete a power share transaction across the Smart Grid.*

A **Query** consolidates ‘Big Data’ from sensors distributed across the IoT. Cubicon utilizes an integrated network/composition schemata model that is consistent across both dynamic and persistent data representations; eliminating data transformation between memory and storage. The schemata model represents unstructured, semi-structured and structured data in normalized forms, therefore minimizing redundancy and dependencies.

The schemata model is capable of processing highly linked information within specific
contexts. Cubicon’s query language captures data in real-time across sensor networks, placing it into marshaled result tables. For highly efficient distributed processing, tables can be persisted as grids. Heterogeneous data is processed across CPU cores on a transactional basis and homogeneous data is processed across GPU cores on a concurrent basis. An example query-based service is to discover, purchase and analyze data gathered by a grid of sensors over a large landmass on a dynamic basis.

An **Inferrer** paves a pathway for an agent’s travel between Topic Maps. An inferrer agent conveys knowledge about a set of Topic Maps by reasoning about their topic characteristics and referenced resource occurrences hosted by Community and Entity Repositories. An inferrer agent navigates between topics to perform this reasoning. An example inferrer-based service might be a surveillance agent that can travel from camera to camera, performing image analysis based on Topic Map reasoning in real time.

A **Signal** gathers periodic data from a sensor thing (mote) – An interruption in the periodic value feed asserts a ‘not available’ status. An example signal-based service is the real-time ambient temperature feed from the North Pole.

A **Concurrent** distributes and collects homogeneous grid data – A large grid of data can easily be partitioned and distributed to multiple servers processing within CubeEngines. An example concurrent-based service is post processing a large grid of sensor data really effectively by harnessing idle compute resources in the cloud.

**Cubicon Opportunity for Carriers**

The opportunity for the wireless network carrier to leverage their networks to support the exchange of M2M and IoT data as value-creation services is restrained by the immense complexity to develop, deploy and maintain these complex distributed systems. Approaches such as Cubicon can provide the prerequisite level of software and solution development and deployment automation to allow carriers and their partners to support authentic, positive change in every domain of human endeavor, and in so doing, harvest the full service revenue creation potential of the IoT, as well as Big Data and ‘The Cloud.’

This automation will enable a carrier to support M2M enablement / exchange services at much lower comparative direct investment or related costs. Automation of these services will also help people and/or machines to take confident, effective actions on high value analytics of M2M and IoT device intelligence databases. Solution vendors, solution integrators and even users will be able to field enablement/exchange services at fractional cost structures.

So what does Cubicon mean for carriers? We think it means enabling the most fundamental shift in their business models since the inception of wireless networks. Cubicon means carriers migrate from selling traffic in commodity markets to selling value across the entire spectrum of enablement and exchange services; applications; and use case scenarios that will help define and realize the future of life, business, healthcare, transportation, hospitality, governance, security and more.

**Multi-sided Producer Revenue Sharing**

This service revenue creation potential of the IoT is currently hampered by a lack of industry standards that would enable broad interoperability between a myriad of new device and thing types. The IoT standardization process is well beyond telephony signaling and
text messaging protocol accomplishments of the past, requiring a meta-standard technology that can automatic the standards making process itself. This automation is required to greatly accelerate the development and deployment of IoT solutions that span multiple wireless networks, (Figure G).

The Cubicon meta-standard technology supports an open, but protected Design Source model that enables direct monetization of software Intellectual Property. The model will enable all IoT stakeholders to participate in the ecosystem while protecting their individual economic interests. Monetization is enabled by contextualization that tracks all service and component exchanges between producers and consumers. Contextualization is the technical foundation for automating M2M interactions to this level of sophistication.

For more information:

Conversation between Joachim W. Walewski (IoT-A) and Sanford Klausner (CEO of CoreTalk) published in the IoT-A Newsletter #4, February 2013-02

Cubicon: Architectural solutions for the Internet of Things slide decks