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Maximizing Mobile Operator Opportunities in M2M

The Benefits of an M2M-Optimized Network

Sponsored by Cisco

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Section 1.

EXECUTIVE SUMMARY

The mobile machine-to-machine (M2M) market is expected to grow from approximately 71 million cumulative connections globally in 2009 to roughly 225 million connections by 2014. This growth in cellular connectivity to machines ranging from vending machines to automobiles is being driven by a number of factors on a global basis:

- Mobile network coverage is being expanded worldwide.
- Telematics and telemetry are seen increasingly as sources of greater operational efficiency and increased incremental revenue.
- M2M applications benefit from R&D and the scale of the mobile handset industry.
- Technical advances in air interface standards are enabling new 3G M2M market segments.
- Mobile network operators (MNOs) are seeking to expand their data service offerings.
- Government mandates are increasingly requiring the use of telematics and telemetry functionality.

As MNOs become more directly involved with M2M application service providers (ASPs), many are deploying key network elements, specifically mobile packet gateways (*e.g.*, Gateway GPRS Support Node – GGSN; Packet Data Serving Node – PDSN; *etc*.), specifically for their M2M operations, separate from their general mobile data infrastructure. Key benefits of doing this include: simplification of internal business operations and optimization of network utilization.

Likewise, mobile virtual network operators (MVNOs) active in the M2M market are also increasingly deploying mobile packet gateways and similar equipment to interconnect with their MNO partners' radio infrastructure. The benefits to the MVNO for doing this include the ability to: create new service offerings independently of their MNO partners and enable quicker provisioning and diagnostic capabilities to their ASP customers.

With the expected increase in the deployment of mobile network elements dedicated specifically to M2M applications, ABI Research believes it is likely that such equipment will increasingly be optimized for the unique needs of M2M applications. For example, mobile packet gateways that are optimized for M2M traffic are designed to handle large number of packet data session activations, rather than provide large amounts of throughput. Fundamentally, there is a range of technical parameters upon which mobile packet gateways can be optimized for M2M application deployment; these are discussed in detail in this white paper.

Deploying such M2M-optimized network infrastructure will enable MNOs and MVNOs to provide a more robust and functional connectivity service to their ASP customers. This serves to differentiate the MNO/MVNO in the M2M marketplace, compete more successfully, and ultimately increase their revenue opportunity. Likewise, the ASP benefits directly from M2M-optimized network infrastructure by being better able to provide their end customers with new features and functionality, as well as more efficient, robust, and responsive services, and thereby differentiate their own offerings in the market. This ultimately results in more revenue for the ASP, as well.

Section 2.

INTRODUCTION

2.1 Research Scope and Objectives

This white paper was prepared on a custom research basis for Cisco Systems to investigate the unique role that Mobile Network Operators (MNOs) can play in providing key network capabilities and benefits in the delivery of Machine-to-Machine (M2M) services. While the research focus of this white paper is on the specific network attributes and features discussed later in the white paper, we also provide context for the technical analysis with a discussion of overall market growth potential and key market trends.

2.2 Research Methodology

This research project consisted primarily of research interviews conducted in January 2010 with leading telecom service providers directly active in the M2M market, including Mobile Network Operators (MNOs), Mobile Virtual Network Operators (MVNOs), and Mobile Virtual Network Enablers (MNVEs). Companies interviewed for this white paper included US, Canadian, European, and Latin American mobile connectivity service providers.

Interviews consisted of direct one-on-one discussions, either in person or via telephone, with executives at these companies to learn their views and their companies' positions on the specific issues outlined above in the Research Scope and Objectives section. Typically, the executives being interviewed were the general manager or "head" of M2M service offerings for their respective companies, although in some cases other staff members were involved in the research process as well, including technical and engineering staff.

In addition to the primary research process described above, ABI Research utilized its existing base of proprietary research content on the M2M market as a secondary source of data to provide a market forecast of total global M2M connections for the period from 2007 to 2014 and to augment a qualitative analysis of overall market trends impacting the M2M market and the specific technical issues addressed in this white paper. ABI Research has conducted research into the mobile M2M market since 2003 and has offered clients a syndicated market research service examining mobile M2M since 2006.

For more information, please see www.ABIResearch.com.

2.3 M2M Concept Definition and Overview

The term "M2M" is gaining traction and currency in the wider IT and telecom industries, but still faces the challenges of malleability and lack of industry-wide acceptance of a precise, common definition. Consequently, ABI Research uses the definition below to set boundaries around the M2M concept in general, for cellular technology as well as for other forms of communication infrastructure.

"Machines" using network resources to communicate with remote application infrastructure for the purposes of monitoring and control, either of the "machine" itself, or of the surrounding environment.

While this white paper focuses on mobile M2M, please note that mobile M2M is but one aspect of a wider concept of connected devices increasingly being referred to as “The Internet of Things” that encompasses not only mobile M2M, but M2M applications based on wireless sensor networking (WSN) technologies, RFID, and other wired and wireless technologies. Also, please note that many in the mobile industry are increasingly regarding connected consumer electronics (CE) as also forming a part of the M2M market.

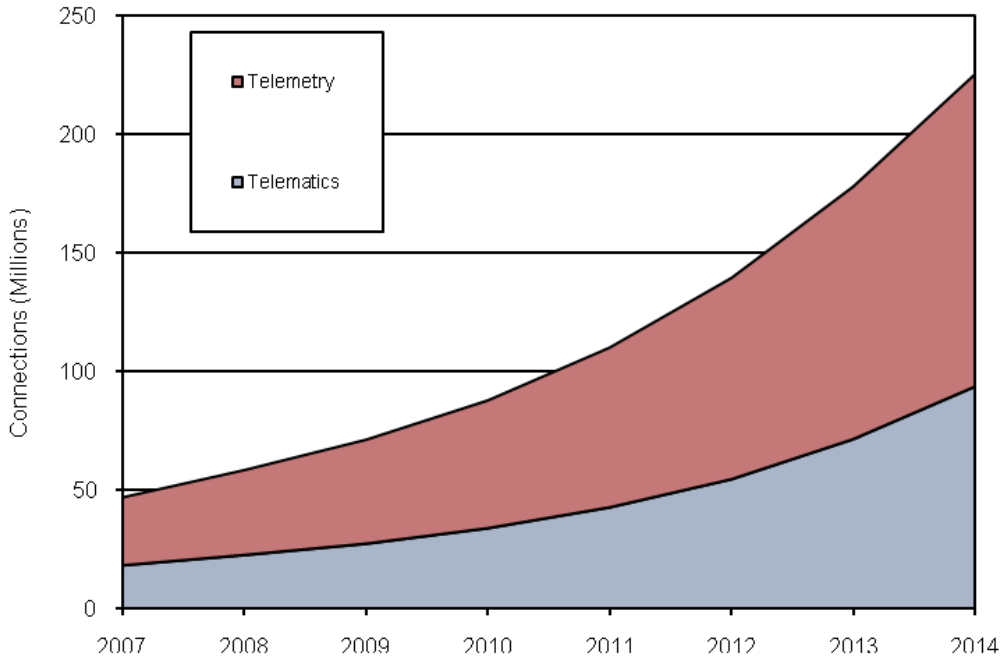
Section 3.

M2M Market Potential

3.1 Global M2M Connection Forecast

As illustrated below in Chart 1.1, the overall M2M connectivity market will grow from 58.29 million connections on a global basis in 2008 to 225.25 million connections in 2014, representing a CAGR of 25%. In 2008, general telemetry applications represented a majority of the market, with 35.81 million connections. General telematics applications combined represented 22.47 million connections. We expect this relative mix to remain the same in 2014, with general telemetry applications retaining the majority share of the market with 131.73 million connections, and general telematics applications adding up to 93.53 million connections.

Chart 3.1 Total M2M Connections by Application, World Market, Forecast 2007 to 2014



(Source: ABI Research)

The global economic crisis has not had as severe an impact on the connectivity service providers as it has on the embedded module vendors. ABI Research estimates that the total number of cumulative global M2M connections still grew by 25% in 2008, rising from 46.78 million connections in 2007 to 58.29 million connections in 2008, although this was down from a 38% growth rate in 2007. Growth in 2009 was at 22%, rising to 71.09 million cumulative connections in 2009.

This comparatively mild impact from the economic crisis is reflective of the cumulative nature of the on-going service agreements that the connectivity service providers make with their ASP customers, in contrast to the module makers' one-off product sales.

One particularly attractive feature of the M2M market for mobile operators is the typically low or non-existent churn among deployed M2M devices in the field in contrast to mobile handsets; when an M2M device has been deployed, it is usually meant to be in the field utilizing the same network for seven to fifteen years, or more. This helps buffer the connectivity service provider level of the M2M value chain from short-term downturns, such as the current economic crisis.

3.2 Key M2M Market Adoption Drivers

The M2M market is comprised of a number of industry verticals and distinct applications, each with its own specific set of market adoption drivers and challenges. Nevertheless, certain general drivers/enablers and challenges/inhibitors tend to impact the M2M market more generally, as discussed below.

- **Mobile network coverage is being expanded worldwide**. Mobile network infrastructure is obviously a fundamental requirement for mobile M2M applications. In North America, mobile coverage was, for many years, insufficient for the needs of long-haul trucking. Instead, satellite connectivity was used, which was both higher in cost and had lower bandwidth. As mobile coverage has expanded in North America, a corresponding shift away from satellite towards terrestrial mobile connectivity in commercial telematics has occurred.
- **Telematics and telemetry are seen increasingly as sources of greater operational efficiency and increased incremental revenue**. Remote equipment connectivity enables businesses to provide enhanced after-sale service and support, such as remote vehicle diagnostics; to offer new or enhanced services, such as mobile POS (Point of Sale) capability at a customer's table in a restaurant, or for in-vehicle multimedia infotainment; and to manage their own assets and infrastructure more efficiently, such as with fleet management or AMI (Advanced Metering Infrastructure).

  In some market segments, such as SCADA (Supervisory Control and Data Acquisition) and fleet management, the benefits of remote monitoring have been recognized for some time. Other market segments, such as consumer automotive telematics and POS, are relatively newer.
- **M2M applications benefit from R&D and the scale of the mobile handset industry**. As with the deployment of cellular network infrastructure, M2M applications benefit from R&D efforts, and semiconductor cost decreases, resulting from the high volume seen in the mobile handset industry. Market development would be severely handicapped if the M2M industry was dependent on supporting R&D and silicon costs solely from the current limited volume of M2M connections.
- **Technical advances in air interface standards are enabling new 3G M2M market segments**. New M2M market opportunities, such as remote video surveillance, remote information display, and multimedia content delivery, and 3G routers/FWTs (Fixed Wireless Terminal), have been enabled by the development of higher throughput air interface standards, such as WCDMA and CDMA EV-DO.
- **MNOs are seeking to expand their data service offerings**. While the major share of MNO data service market development efforts consists of increasing subscriber adoption of mobile broadband services, enabled through PC Cards and embedded modules in laptop PCs, some MNOs see M2M as a strategic service offering. MNOs, such as Sprint, AT&T, Verizon Wireless, Orange, Rogers Communications, Telenor, Telefonica, and NTT DOCOMO, are actively deploying M2M-based services.
- **Government mandates are increasingly requiring the use of telematics and telemetry functionality**. Various governments and regulatory bodies around the world are enacting regulations that mandate functionality of the type enabled by M2M. While mandates rarely require that a specific technology be used, M2M is often seen as a viable way of enabling AMI, telematics, and POS directives.

For example, Sweden mandated that all of its national utilities must read their electricity meters at least once a month, starting in 2009. Swedish utilities are using mobile connectivity as part of the AMI solution, and other Scandinavian countries are expected to follow suit. The European Commission is promoting an EU-wide "eCall" telematics initiative with the goal that all vehicles sold in Europe by 2013 will use a combination of GPS, sensors, and mobile communications to automatically notify authorities in the case of an accident with location and details of the incident, and establish an automatic voice call between passengers and emergency personnel.

3.3 Key M2M Market Adoption Hurdles

- **Knowledge and experience of M2M is still limited and substantial customer support is often required**. M2M is typically an enabling technology; it is integrated into existing applications that were developed without reference to eventual integration and support of cellular technology. Consequently, the industry faces an educational challenge on two levels. First, potential customers simply may not be aware of cellular M2M technology and how it might benefit their product or service offering. Second, once they are aware of M2M technology, they are likely to be ill-equipped to integrate it into their product or service offering.
- **Many cellular M2M applications can be complex to develop and deploy, especially for companies whose core businesses are in non-technical areas**. Expanding on the bullet point above, many potential customers will find it challenging to integrate cellular M2M technology into their existing products and services. This includes physical component integration and product redesign, in the case of utilizing modules.

  At a minimum, a TCP/IP (Transmission Control Protocol/Internet Protocol) stack and embedded application software will be needed in the remote device, and the node will need to be integrated through middleware and enterprise application software to the company's back-end enterprise infrastructure, for a complete solution. This challenge is growing, as added functionality becomes integrated into the remote device, such as GPS tracking capability, Bluetooth, and other forms of SRW (Short-Range Wireless) connectivity.
- **The cost of M2M solutions can be an inhibitor for some applications**. Apart from basic WLL, mainstream wireless modules range from approximately $25 to $90. These cost points make them difficult to integrate into some end devices, such as utility meters. A key reason for integration of ZigBee and other SRW and PLC (Powerline Carrier) technologies into utility meters for AMI applications is that many utilities do not feel a financially sound business case can be made for the integration of a mobile connection into every meter. Rather, a single meter, or concentrator, receives a mobile connection and is, in turn, connected to a group of local meters through less-expensive SRW or PLC connections.
- **Third-generation M2M applications are dependent on the deployment of 3G mobile infrastructure by MNOs**. CDMA EV-DO and WCDMA network infrastructure is being deployed quickly in certain regions, notably in North America, Europe, and parts of Asia-Pacific. However, Latin America, other countries in Asia-Pacific, and the Middle East & Africa regions are seeing slower adoption of 3G infrastructures, which limits the ability of customers to deploy 3G M2M applications in these areas.
- **Many applications have a limited need for high throughput 3G connections**. Many M2M applications simply do not need the high throughput of 3G connectivity, which is an inhibitor to the adoption of 3G M2M technology. For example, current mainstream telematics, general fixed telemetry, AMI, security, vending, and POS do not inherently need 3G connections for the core application to function well. Moreover, many of these applications are cost-sensitive, and the cost differential between 2G and 3G connectivity may further inhibit a change to 3G. As a counterpoint, it should be noted that, in some instances, these applications may be enhanced with multimedia functionality, such as telematics infotainment or advertising/promotional content delivered through kiosks or ATMs. Further, some MNOs are encouraging the shift of data devices to 3G networks for spectral efficiency.

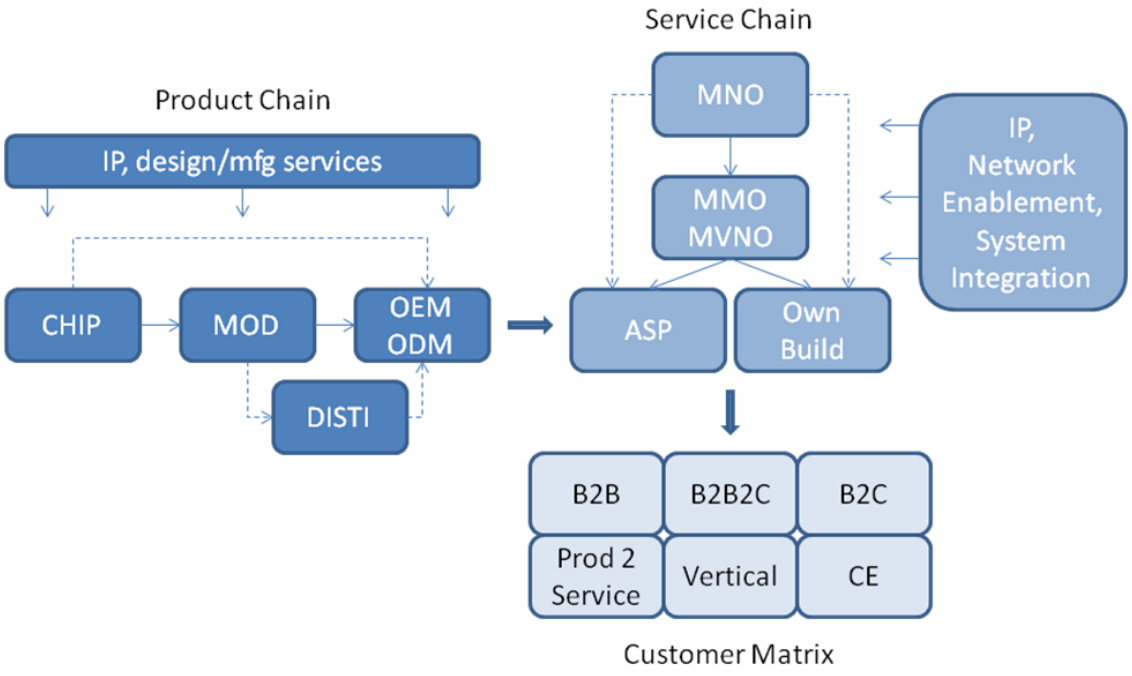
Section 4.

MNOs and MVNOs in the M2M Market

4.1 Traditional Value Chain

Figure 4.1, below, illustrates a basic view of the mobile M2M value chain. In this white paper, we focus on the "Service Chain" segment of the market. This section of the white paper specifically discusses trends in the service chain and the evolving relationship between MNOs, MMOs/MVNOs, and ASPs within the M2M market. In particular, we note how MNOs are increasingly working directly with ASPs and companies building their own M2M applications internally, in addition to working with MMOs (connectivity service providers that maintain their own network elements), MVNOs, and master VARs on a wholesale basis.

Figure 4.1 Mobile M2M Value Chain



(Source: ABI Research)

4.2 Current Value Chain Trends

The volume and revenue opportunities associated with the M2M market in its earliest stages were typically not attractive enough to draw much direct interest on the part of traditional links in the mobile value chain, such as chipset providers and MNOs. M2M applications are often different enough from voice and data handset applications that these traditional value chain players would have to expend more resources in modifying their go-to-market strategies than could necessarily be justified by particular M2M business opportunities.

Consequently, specialized links in the mobile value chain have developed to serve the market gaps created by the relative lack of direct chipset vendor and MNO participation. Module vendors in product chain have taken the lead in designing and pre-certifying with MNOs radio sub-

components that take a significant burden away from ASPs who may not have significant RF design expertise in-house. Likewise, MVNOs and, more recently, MMOs, have provided a valuable service layer between the MNOs and the ASPs enabling the unique connectivity needs of M2M applications to be met in an economically justifiable manner.

Within the past 18 to 24 months however, the mainstream mobile value chain players have pushed much more directly into the M2M market. In the service chain, MNOs are increasingly working directly with ASPs as they see their core data markets maturing and saturating and a new high-growth opportunity in connected CE devices and traditional M2M applications.

4.3 MNO Strategies

MNOs working directly with ASPs typically go after the highest volume opportunities first, the "low hanging fruit" of the M2M market. Consequently, we have seen Verizon Wireless in the United States work with General Motors' OnStar division for consumer telematics, and AT&T and Sprint work with various connected CE device applications, such as eReaders.

In addition to focusing on the highest volume M2M market segments, MNOs have typically taken a number of additional market- and technology-oriented steps to optimize their go-to-market strategies for M2M:

- Creating a distinct M2M business unit within the larger MNO organization. Within European MNOs, the M2M business unit typically forms a single international organization to handle M2M activities across the various "local" country-level MNO business units.
- Often, but not always, deploying M2M-specific, dedicated network elements, specifically mobile packet gateways (*e.g.* GGSNs, PDSNs) and HLRs, in support of their M2M business units.
- Continuing to work with MVNO partners for smaller scale and more specialized (and complex) M2M applications. In addition, announcements have been made of MNOs utilizing MVNO partners to help certify and "on-ramp" M2M devices onto the MNO network more quickly, such as the case with Sprint and M2M DataSmart, and AT&T and KORE Telematics.
- In some cases, MNOs are working with enabling organizations to help them deploy optimized M2M technical and marketing functionality. This is most directly seen in the work Jasper Wireless is doing with MNOs such as AT&T, KPN, Rogers Wireless, Telcel, and TIM Brasil, and Verizon Wireless' joint venture with Qualcomm in nPhase.

4.4 MVNO and MMO Strategies

MVNOs have played a pivotal role in the early development of the M2M market and it is likely the will continue to play an important role over the near- to mid-term. However, as MNOs push more directly into the market MVNOs face an increasingly complex market environment. Fundamentally, MVNOs are likely to find the most success focusing on the more specialized, "niche" segment of the M2M application market and utilizing their expertise and capabilities to bring more complex applications to market. Also, forming a tighter collaboration with MNOs to help the MNOs with quicker on-ramping of devices onto MNO networks is also likely to prove successful for the MVNOs.

In addition, an increasing number of MVNOs, such as Aeris Communications and Numerex in the United States and Wireless Maingate in Europe, have deployed their own network infrastructure, specifically mobile packet gateways and HLRs, to use in conjunction with MNO partner radio infrastructure. It is important to note that not all MNOs are willing to accept direct HLR and mobile packet gateway interconnection with their mobile radio infrastructure from non-MNO partners. ABI Research classifies MVNOs who have deployed HLRs and mobile packet gateways as "MMOs" due to the differing nature of the relationship between the MNO and MMOs from that of the MNO and MVNO.

Section 5.

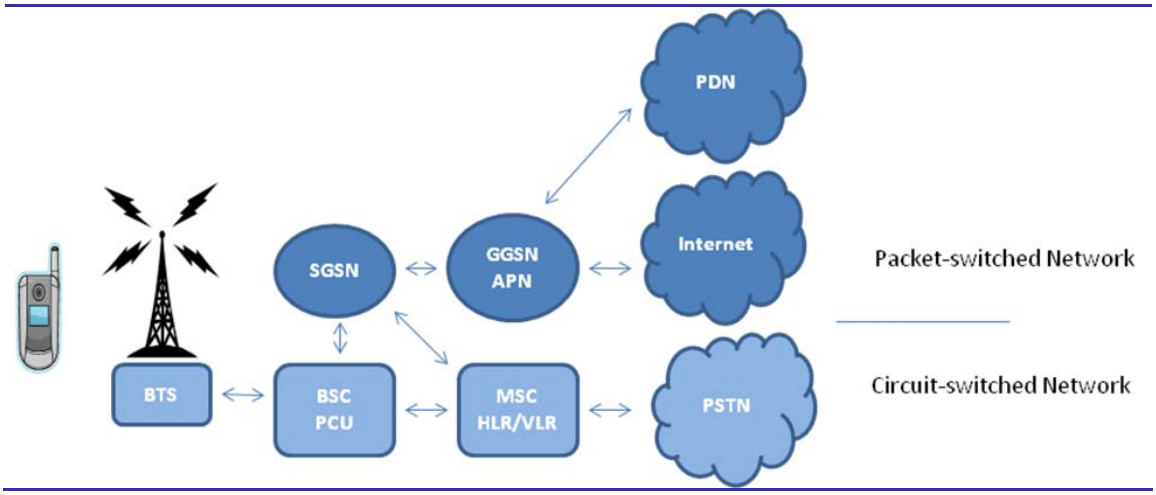
CORE MOBILE NETWORK ELEMENTS FOR M2M: NEEDS AND BENEFITS

5.1 Mobile Network Architecture for M2M

As we discussed previously, when MNOs deploy M2M-dedicated network elements, and when MVNOs/MMOs deploy their own network elements to use in conjunction with their MNO partners' radio infrastructure, the two key elements they are deploying are the mobile packet gateway (*e.g.*, the GGSN in a GSM radio network) and the HLR. We will briefly discuss how these two elements fit into the overall mobile network and then delve more deeply into the key capabilities needed for M2M-optimized mobile networks.

Figure 5.1 illustrates a basic GSM/GPRS network diagram, although fundamentally the same basic logical elements and relationships exist in CDMA and UMTS networks as well. LTE will entail some fundamental differences from the figure below, however, as 4G LTE will eventually comprise an all-IP network.

Figure 5.1 Simplified GSM/GPRS Network Diagram



(Source: ABI Research)

The GSM/GPRS mobile network essentially comprises the circuit-switched voice network that connects mobile handsets with the public switched telephone network (PSTN). Overlaid on top of the GSM voice network is the GPRS packet-switched data network. Although circuit-switched SMS messages are used in M2M applications, increasingly M2M data is sent in packet format.

Base station controllers (BSCs) control a number of base transceiver stations (BTSs) that control the actual radio towers. Packet control units (PCUs) transfer packets bound for the GPRS network to a local serving GPRS support node (SGSN). Home location registers (HLRs) are a function on both the GSM and GPRS network, and essentially serves to identify mobile stations/end-points with specific account information.

Packets bound for external networks (*e.g.,* the Internet or corporate private data networks (PDNs)) pass through a mobile packet gateway, in this case the GGSN. Each GGSN contains a number of virtual and physical access point nodes (APNs) that define the specific external network, whether public or private, to which the packet is destined.

Mobile packet gateways like GGSNs along with HLRs are two of the most critical network elements relative to M2M service deliver in the mobile network. Mobile packet gateways provide security, Quality of Service (QoS) enforcement, and interaction with charging and billing systems for mobile data service. Mobile packet gateways are also central to interconnecting the mobile infrastructure with 3rd-party networks, most importantly ASPs in the case of the M2M market. HLRs are critical to service creation and management of remote devices in the field.

5.2 The Trend towards Dedicated M2M Network Infrastructure Deployment

MNOs and MVNOs/MMOs are increasingly deploying network elements (GGSNs and HLRs) specifically for the provisioning of M2M services. In the case of MNOs, separate network elements provide several benefits:

- **Simplification of internal business operations**: an M2M business unit within the MNO can run all M2M data traffic over the dedicated M2M network elements, without having to negotiate with other business units for access to the core data network. This is important because negotiation with other business units can lead to lags in service provisioning.
- **Optimization of network utilization**: The separate sets of network elements, for traditional data services and for M2M, can be optimized for their respective needs and use cases. For example, processor cards on the M2M mobile packet gateways can be architected for larger numbers of connections but lower throughput per connection.

For MVNOs deploying their own mobile packet gateways and HLRs (and thereby become MMOs), the key benefits are the ability to:

- **Create new service offerings independently of their MNO partners**: For example, at the Distributech trade show in 2009 Aeris announced a two-way broadcast paging service running over CDMA (rather than ReFLEX or some other 1G air interface standard).
- **Enable quicker provisioning and diagnostic capabilities to their ASP customers**: MVNOs working as re-sellers of airtime essentially have to work through their MNO partners to create service tickets on behalf of their ASP customers. While extremely large MVNOs can negotiate excellent deals with the MNOs for rapid MNO response, in general the use by the MMO of its own network elements offers the ability to directly control and thereby speed up these important M2M business functions for their customers.

5.3 Key Technical Capabilities of M2M-Optimized Networks

ABI Research believes that the mobile M2M market will undergo an evolution from simply using separate, but still general-purpose, mobile network elements to deploy M2M services, to using equipment that has been specifically optimized for the needs of the M2M market. Such optimized equipment affords the MNO/MVNO the benefit of being able to provide a more intelligent network to their ASP customers and thereby differentiate their connectivity offering, compete more successfully for ASP business, and, ultimately, to garner more revenue from selling connectivity services for M2M applications.

Likewise, for the ASP, an M2M-optimized mobile network infrastructure provides them the ability to better serve their end customers with new features and functionality, more efficient, robust, and responsive services, and thereby differentiate their own offerings in the market and deepen their own customer relationships. This ultimately results in more revenue for the ASP, as well.

Below are several of the characteristics that are likely to be integrated into such "M2M-optimized network elements."

5.3.1 Activation Rates Optimized for the "Internet of Things"

Mobile data applications based on smartphones and PC modem devices primarily need high throughput at the mobile packet gateway for a successful user experience. In contrast, most M2M applications typically have low throughput requirements as they are only sending small amounts of data, often intermittently or even on an exception-only basis. M2M applications do benefit from the ability of the mobile packet gateways to rapidly scale up to a large number (*e.g.,* hundreds of thousands or millions) of "PDP context" activations; that is, the activation of an open packet data session between the remote device in the field and the mobile network infrastructure and, by extension, the application back-end infrastructure.

If very large numbers of remote M2M devices were to attempt to initiate an active context/session after recovery of the local mobile network infrastructure from a catastrophic outage, for example, it would be critical for the mobile packet gateways to have the ability to adequately scale up to initiate the contexts and properly connect them to the appropriate back-end networks.

5.3.2 Stateful Geo-redundancy for Session Recovery

Following on from the use case example described above in section 5.3.1, there is a need to have mobile packet gateways, *e.g.*, GGSNs that not only scale up to a large number of PDP context activations, for example in response to disaster recovery, but also to be able to shift those sessions over to a second GGSN in a stateful manner should the first GGSN go down.

Stateful IP packet session failover has the benefit of being able to keep the state of the sessions active within the GGSNs directly, without having to flood the ASPs RADIUS servers with a huge signaling storm and potential crash as a multitude of remote M2M devices try to connect. Fundamentally, as the context states are maintained directly in the M2M-optimized GGSN, this enables the ASP to work with more cost optimized server technology that does not need to support millions of activations simultaneously, as the GGSN takes on this burden in the context of geo-redundancy.

5.3.3 IPv6 Support for Network Address Availability

On January 19th, 2010, the Numbers Resource Organization, the entity tasked with protecting the un-allocated pool of remaining IPv4 Internet addresses, issued a statement indicating that less than 10% of IPv4 addresses remain un-allocated. Clearly, if millions to hundreds of millions of new devices are going to be networked in an "Internet of Things" in the coming years, this shortage of IPv4 addresses poses a challenge, particularly for countries outside of North America that were allocated comparatively fewer IPv4 addresses to start.

While there are technical short-term fixes to this dilemma, including dynamic IP addressing, the optimal long-term solution is a shift to IPv6, which enables orders of magnitude larger numbers of available IP addresses. Most MNOs are in the planning stages for this transition to IPv6, or have already made the transition. M2M-optimized mobile infrastructure can help with the transition by future-proofing applications through the use of techniques such as IPv6 tunneling over IPv4. Essentially, this capability would enable remote M2M devices to use native IPv6 addresses that are translated to IPv4 for transport across intermediate networks to the ASPs private data network.

5.3.4 Network-Initiated Data Session Activation for Increased Application Robustness

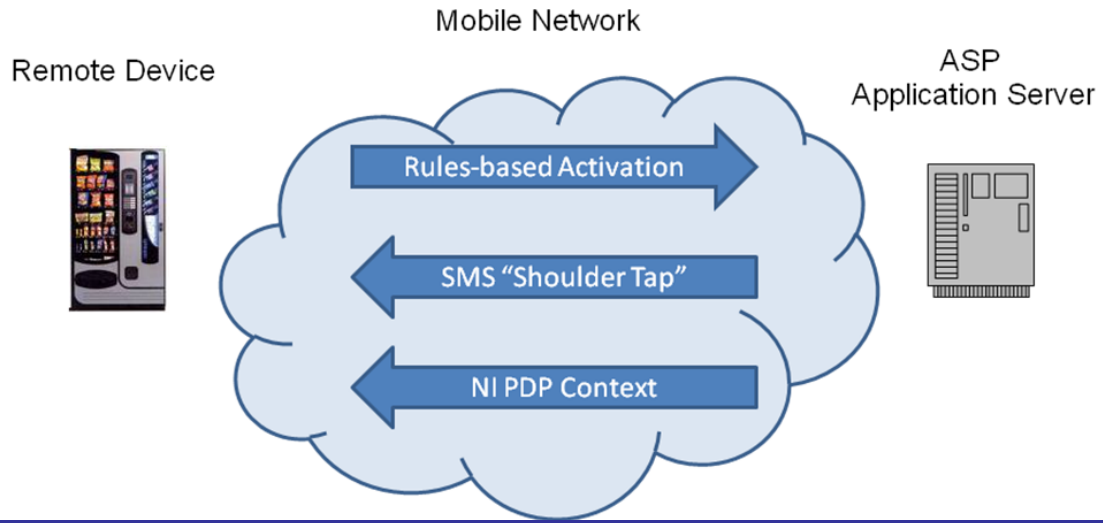
Very large numbers of data-capable devices are coming onto mobile networks, both for M2M as well as traditional smartphone and PC connectivity. While M2M-optimized network elements can aid in managing extremely large numbers of PDP context activations, MNOs are still becoming more concerned about reducing idle time to make their networks more efficient. It is becoming increasingly common for MNOs to require idle devices (that is, remote devices that have an active packet data networking session in place – PDP context – but are not actually transmitting data) to drop their session after one to four hours of inactivity. This frees up network resources for other remote devices to activate PDP contexts.

It is not too significant a burden for traditional smartphone and PC modem data users to have a context dropped if idle; if the session is idle they are simply not using the service and can renew the PDP context as soon as they need to be reconnected.

For M2M applications, decreasing idle time can be a significant burden, as it is often the server-based application software that needs to communicate with the remote device. Take, for instance, a new emergency firmware upgrade that needs to be immediately delivered to a set of remote devices. Given that with traditional mobile network functionality PDP contexts cannot be initiated from the network side, that is, by the server-based application software, ASPs have needed to rely on either rules-based embedded software on the remote device telling it to initiate a PDP context at certain intervals or at certain specified events, or have had to rely on SMS "shoulder-taps" to cause the remote device to initiate a PDP context.

Figure 5.2, below, illustrates the three options for initiating a PDP context between a remote device and the back-end M2M application server.

Figure 5.2 Data Session Activation Technology Options



(Source: ABI Research)

The challenge with a rules-based paradigm is that the remote device's embedded set of rules may not lead it to initiate a PDP context when the server-based application software would like it to do so, as in the case of the emergency firmware download described above. The challenge with SMS "shoulder-taps", wherein the server-based application software sends an SMS to the remote device, which is allowed under traditional mobile network functionality, is that SMS messaging is not always seen as reliable enough for some M2M applications; there's the possibility that the message is unacceptably delayed or never delivered at all.

A newer capability emerging in some mobile packet gateways (*e.g.*, GGSN) provides a way for the ASP's server-based application software to initiate a PDP context with a remote device, called a "network initiated PDP (NI PDP) context". When the MNO or MVNO receives an IP packet from the ASP's application destined for one of its remote M2M devices, the GGSN checks if a PDP context is already established. If not, the GGSN interrogates the HLR from the IMSI identifier of the M2M device to retrieve the appropriate SGSN address, to which it sends a request to initiate a PDP context activation. The SGSN then sends to the M2M device a request to activate the PDP context. MNOs/MVNOs that provide this capability could enable ASPs to have a more robust capability to contact their remote devices, while also addressing the MNO goal of minimizing idle PDP contexts.

5.3.5 Mobile Packet Gateway Virtualization for Quality of Service

M2M application service provisioning typically involves more stringent service level agreements (SLAs) made to the ASP by the MNO or MVNO than what is provided to data smartphone and PC modem users. Certainly it can be an irritating inconvenience to mobile handset/laptop users when their connection goes down or is not robust. But for some M2M verticals, for example telehealth or certain industrial monitoring applications, the need for a high level of quality of service (QoS) is typically more business-critical than in the consumer market.

Many MNOs that are becoming more actively involved in the M2M market are deploying M2M-specific network elements expressly for the purpose of being able to offer improved QoS and more robust SLAs. Taking this basic trend a step further, some mobile packet gateways are capable of partitioning system resources among various customers. This prevents traffic bound for one ASP from potentially negatively impacting the traffic of another ASP. Virtualization is also a very cost-efficient means to provide per ASP QoS in contrast to dedicating specific hardware resources to different customers. Such dedicated hardware will typically mean more blades and boxes than would otherwise be required in a virtualized context.

5.3.6 Diagnostics for Services Troubleshooting

One of the fundamental shifts in the interaction between MNOs and MVNOs with their ASP customers has been the enabling of ASPs to self-provision, manage, and troubleshoot their active devices in the field. From the connectivity service provider perspective, this is far more efficient than having to manage these processes directly. Likewise, from the ASP perspective, this provides far greater granularity of control and ability to interact with

However, managing mobile network-attached devices is far more complicated than managing devices connected to the wireline network. These challenges range from bandwidth typically being scarcer on mobile networks to protocol issues between GSM and GRPS that can make a connection appear active because it has GSM connectivity even though the ability to send packets over GPRS is inoperable.

The ability to perform diagnostic analysis on the control and data traffic between the remote device and the server-side M2M application software is one important means to increase the capability of MNOs and MVNOs to provide a robust self-management platform for use by their ASP customers. For example, this gives the ability for the ASP to know if a device is inoperable due to coverage loss, because it was physically shut off, or if there is a particular malfunction with the device itself.

Section 6.

CONCLUSIONS AND RECOMMENDATIONS

6.1 MNOs

MNOs already operate the entire network infrastructure needed to offer mobile data service and deploying specific network elements is not an absolute requirement for them to be active in the M2M market. Nevertheless, many MNOs do find that separate, M2M-specific network elements do offer a number of benefits, as discussed above in section 5.2. As the number of M2M devices increases in the field, ABI Research believes many MNOs will find they pass a threshold at which it simply makes more financial and operational sense to split M2M devices onto separate network elements than to continue to run all traffic over the same network.

Further, we believe that as increasing numbers of MNOs deploy M2M-specific network elements, they will also seek to use the opportunity of the M2M-specific use case to optimize the infrastructure for the specific needs of M2M applications. The technical benefits of M2M-optimized network elements, specifically around the mobile packet gateway, outlined previously in section 5.3 are available today in equipment from networking and telecom equipment providers. Fundamentally, deploying M2M-optimized network infrastructure will enable MNOs to provide a more robust and functional connectivity service to their ASP customers. This serves to differentiate the MNO in the M2M marketplace, compete more successfully, and ultimately increase their revenue opportunity.

While we have focused on the mobile packet gateway and the HLR in this white paper, it is important to note that other elements and capabilities, specifically billing systems and management portals (also known as connected device platforms) are also important in an M2M-optimized network infrastructure. More flexible billing systems allow the MNO to respond in a more innovative fashion to the needs of M2M ASPs; for example, bundling in airtime with the purchase of an eReader, to obviate the need for the eReader buyer to commit to yet another subscription.

6.2 MVNOs

MVNOs have built successful businesses re-selling MNO airtime to ASPs in a way that meets the specific and unique needs of the M2M market. Some of the very largest of the MVNOs have been able to develop very close relationships with their MNO partners such that they have the ability of offer services that appear little different from what could be offered if they indeed had their own HLRs and mobile packet gateways.

Nevertheless, as outlined above in section 5.2, there are real, material advantages for MVNOs to deploy their own network elements, including mobile packet gateways, to intersect with their MNO partners' radio network infrastructure. As with MNOs deploying M2M-specific network elements, we believe that MVNOs increasingly will choose equipment that is technically-optimized to serve M2M applications, rather than deploying generic data infrastructure. No less than for the MNOs, M2M-optimized equipment enables MVNOs to differentiate the connectivity service offering to their end-customers and thereby increase their revenue opportunity.

6.3 ASPs

Likewise, for the ASP, M2M-optimized network infrastructure provides the benefit of being better able to serve their end customers with new features and functionality, as well as more efficient, robust, and responsive services, and thereby differentiate their own offerings in the market and

deepen their own customer relationships. This ultimately results in more revenue for the ASP, as well.

Technical details of the underlying mobile network infrastructure supporting their businesses are opaque to many ASPs. However, ASPs have a vested interest in the capabilities of their connectivity partners. The network infrastructure deployed by MNOs and MVNOs directly impacts the capabilities of an ASP in such areas as rapid service creation, ensuring a high level of QoS, and enabling granular management and diagnostic tools. In short, the underlying MNO/MVNO network infrastructure impacts on the ability of ASPs to enhance their own service offerings to their end customers and thereby increase revenue.

As we have described in this white paper, ABI Research believes that mobile network elements will be increasingly optimized for the specific needs of M2M applications, and that there will be a corresponding increase in the differentiation among connectivity service providers in the capabilities they can offer to their ASP customers.

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