Machine to Machine (M2M)

Industry's focus on the R&D of entire M2M solutions

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***Abstract* – M2M is an abbreviation for machine-to-machine or technology that supports wired or wireless communication between devices. Today the cellular networks are well-suited to offer the connectivity for a range of different M2M applications and operators are increasing their focus on the M2M space, particularly in mature, saturated markets globally. M2M is majorly used in the following industries: Communication, Utilities, Automotive, Transportation, Manufacturing, Security and Healthcare. Telecom vendors and providers are actively working with these vertical segments to simplify the value chain for M2M solutions.**

Keywords- M2M, Sensors, Devices, Applications, Networks, Templates, Market Segment, Service Enablement, Optimization

I. INTRODUCTION

M2M is defined as "the ability of applications to connect with remote devices, equipment, and sensors over cellular networks for the purposes of automated monitoring and control, or transparent content delivery." M2M uses a device (sensor, meter, etc.) to capture an 'event' (temperature, inventory level, etc.), which is relayed through a network (wireless, wired or hybrid) to an application (software program), that translates the captured event into meaningful information (e.g. items need to be restocked).

Wireless and Wireline systems already support the basic communication capabilities for the M2M communication. The challenge is to be able to deploy, communicate and manage these systems efficiently and economically. Standardization is a key to achieve the protocol optimizations and the economies of scale needed for cost effective deployments.

The wireless M2M is applied on commonly used wireless wide area network technologies such as GSM/GPRS/EDGE, WCDMA/HSPA, CDMA and LTE. The M2M communication is characterized for long mostly by small data transfers with high requirements on geographical coverage. Many deployments which are large in volume are under 2G network as the module prices are lower than 3G/4G and LTE. The mobile network operators (AT&T, DoCoMo) are gradually stopping the addition of new 2G M2M applications and focusing on new deployments on the upgraded technology with step-by-step phase-out of legacy networks.

As the M2M market is maturing gradually, the operators are making strategic choices and directly involving into the market. Industry continuously provides support for M2M end-to-end, from strategy definition to the technical implementation and realization.

Industry predict growth numbers around 25 percent CAGR the coming five years (2013-2017).In 2017 it is expected that somewhere between 440 and 540 million devices will be connected on the cellular networks, generating some $100 billion USD in revenue.

II. ELEMENTS OF M2M SOLUTIONS

All wireless M2M solutions comprise three core elements – devices, networks and applications.

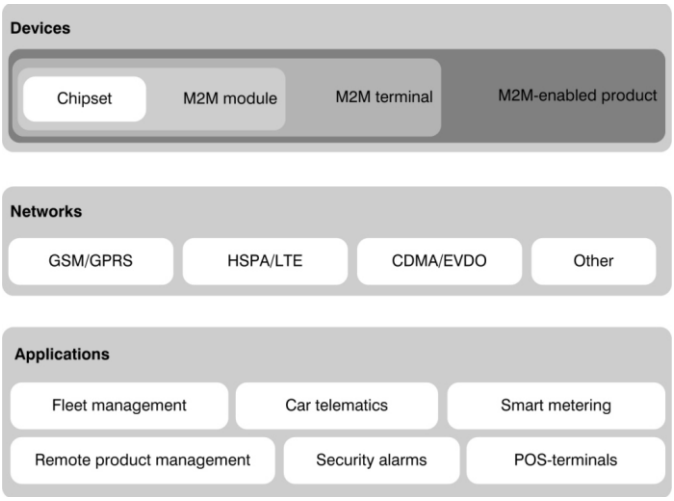

Fig 1: Core elements of wireless M2M solutions

Devices are based on cellular chipset technology, generally packaged as M2M modules that form part of an M2M terminal which is integrated with a complete product. Networks are public cellular infrastructure or in some cases private special purpose networks. Common applications include car telematics, fleet management, smart metering, remote product management, security alarms and POS-terminals.

ISBN: 978-81-923777-9-7

Devices –

An M2M device contains mainly a communication module (short/long range) and optionally sensing/actuation capabilities (e.g. electric energy sensor), processing, storage modules and localization capabilities.

Cellular chipset technology is at the core of all wireless M2M devices. They share the same technology platform as other cellular devices such as handsets and USB-modems.

Product development at chipset level is very complex and time consuming. So developers use ready M2M modules in standard form factors that can easily be embedded on existing circuit board designs.

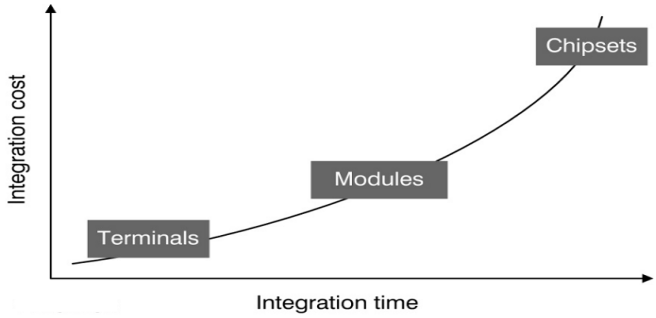

Fig 2: Cost vs time for wireless integration

M2M modules are communication devices that can be embedded into machines to send and receive data and voice transmissions via cellular networks. Next this module is packaged as part of a purpose-built M2M terminal which in turn is integrated with the final solution. There are many M2M terminals and devices purpose built for various applications. Some terminals, like alarm communicators and vehicle telematics systems are purpose built for specific applications, enabling OEM and upgrades of existing products.

There is a trend to define common interfaces to M2M devices, driven by both cost reduction and re-use of devices for many purposes.

Networks –

Any communication network may accommodate M2M applications, like fixed-line networks can be used for monitoring fixed assets and wireless networks can be used under all circumstances even though they are required for mobile assets.

GSM-family technologies support packet switched and circuit switched data communication with widely use of SMS for transmitting short data messages. EDGE is a bolt on enhancement of GSM for increased data transmission rates and enhanced radio spectrum utilization. HSPA is the latest addition in the GSM-family of mobile technologies, developing the performance over WCDMA networks to improve coverage and reduce radio energy consumption. The CDMA is available for a very broad spectrum of frequency bands and it is highly efficient for providing coverage in sparsely populated areas. CDMA technology is today commercially available by CDMA 2000, RTT, EVDO, Rel 0 which are evolutionary technology used for increasing the data rates and reducing network latency.

LTE is the next step evolution for fourth generation mobile communication technology which is compatible with GSM, HSPA and CDMA. The operators are choosing LTE for future networking platform.

3GPP radio technologies will efficiently support M2M services in the following fields by 2016+:

Technologies	M2M Services
2G GSM/EDGE	support cheap devices and battery efficient operation
	support only low QoS and is not very spectrally efficient
3G UMTS/HSPA	provides high performance and demanding QoS, and it is spectrally efficient
	will not be battery efficient, nor particularly scalable
4G LTE	adaptive for battery efficient operation, provide a wide range of QoS support and be spectrally efficient
	most versatile technology for M2M
	more complex and at higher cost point compared to GSM

Applications –

Today M2M wireless applications are implemented in all industry sectors. The M2M network technologies and levels of application suitability are given below:

	Cellular	Fixed broad band	PSTN	Wi-Fi	Satellite	Other wireless	PLC	Short-range wireless
Consumer electronics	✓✓✓			✓✓✓	✓	✓✓		
Fleet management	✓✓✓			✓	✓✓✓			
Telematics	✓✓✓			✓	✓✓✓			
Smart meter	✓✓	✓	✓	✓✓		✓✓	✓✓✓	✓✓
Other utility	✓	✓	✓			✓	✓	
Home automation	✓	✓✓✓	✓	✓✓✓			✓	✓✓
Health	✓✓			✓✓				
Industrial	✓	✓	✓	✓				
Asset tracking	✓				✓✓✓			

Fig 3: M2M network and levels of application

Fleet Management: support all logistics and field operations.

Asset management: enable remote equipment monitoring in the Oil & Gas, Basic Materials, Telecoms and Utilities sectors.

Car Telematics: implemented by automobile industry players, by providers of specialised consumer services such as

ISBN: 978-81-923777-9-7

maintenance, safety, anti-theft, entertainment and by non-life insurers as a part of innovative motor insurance products.

POS Terminals: used by retailers, banks and financial services providers using wireless communication.

Security Alarm: used in the Consumer Services and Industrial Goods & Services sectors.

Remote Control and Monitoring: found in the Industrials, Consumer Goods, Technology and Healthcare sectors.

Consumer electronics: used by companies in the Consumer Goods, Technology and Healthcare sectors.

III. M2M WIRELESS ARCHITECTURE

The simple M2M Architecture is showing below.

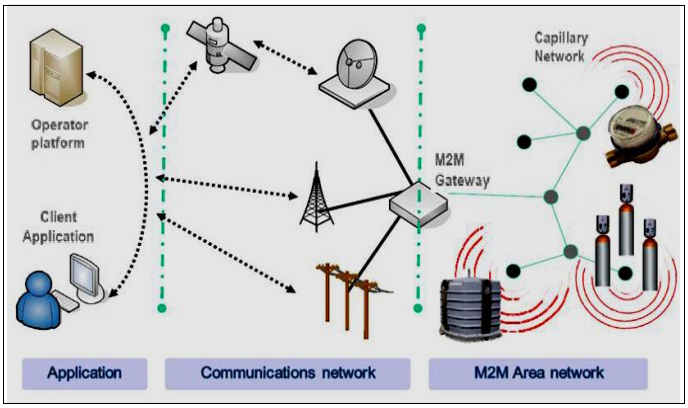

Fig 4: Simple M2M Architecture

The M2M Area network has the following major areas:

Capillary Network: It is an autonomous, self-contained systems of M2M devices that may be connected to the cloud. The sensors, communication and processing units act as endpoints of M2M applications and together constitute the capillary network. It is not just a network that provides access and connectivity to the M2M devices but it can also host application logic in the form of application servers for autonomous operation.

M2M Gateways: The Gateway module provides control and localization services for data collection. It concentrates M2M traffic towards the Telco's core on one side and interconnects with the capillary network on the other. It supports wireless communication standards like GSM/GPRS, Bluetooth/IEEE.

M2M Application Servers: It contains the middleware (application, services, and data) which hosts the business intelligence for execution of the M2M business logic. M2M applications will be based out of industrial grade application servers provided by the operators. Technically, it is a software process or agent by which the data can be captured, analyzed and reported.

M2M Backhaul: It supports Communications between M2M Gateways and M2M Application (server) which is inclusive of technologies as xDSL, Satellite, LTE, GERAN, UTRAN, PLC, W-LAN and WiMAX.

IV. M2M SE ARCHITECTURE

The horizontal architecture for M2M Service Enablement (M2M SE) is proposed to define generalized enablers that can be used for future solutions in the M2M service enablement area.

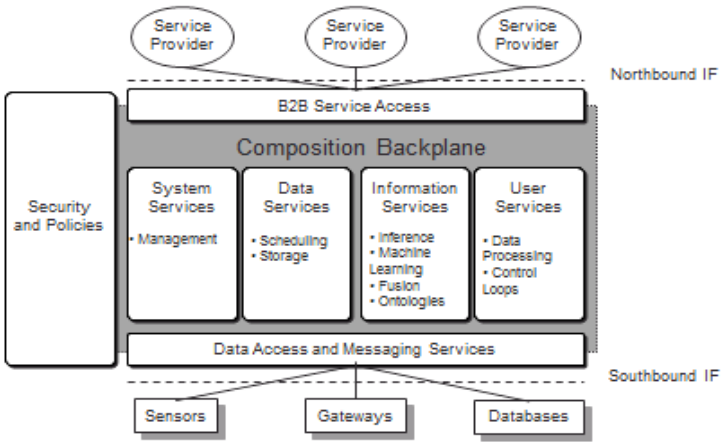

Fig 5: M2M SE High Level Architecture

This follows a service oriented architecture design both from an external and an internal point of view.

From external point of view, the implemented architecture

a) *provides* a set of services towards services users (M2M service/Solution providers like IBM, Ericsson, Accenture) through a northbound interface.

b) *uses* other services from devices or data sources through a southbound interface

From internal point of view, the architecture consists of a set of basic functional components that provide basic services which can potentially be exposed towards the M2M SE users.

The architecture allows more services to be composed from the mentioned basic ones using a **Composition Backplane**.

Data Access and Messaging consists the Data Message Bus (DMB) that connects between the M2M SE users and the devices and the data sources using simple messaging through different access technologies (e.g. SMS, IPv4/IPv6, GPRS).

ISBN: 978-81-923777-9-7

Data Services cover the core services handling raw data routed to/from the communication end points like collection, access and storage of data.

System Services include all management functions of the architecture that can be exposed to the SPs as a service.

Information Services contain domain specific data services that facilitate the processing of raw data into information (e.g. context information) which is meaningful to the service users.

User Services include any specific and advanced data processing services or control loop services.

B2B Service Access facilitate the B2B interactions between the external M2M SE users (SPs) and the internal functional components of M2M SE platform providing access control and forwarding services.

Security and Policies which includes among others AAA for SPs, devices, databases and access control on the data and information offered by the M2M SE.

V. OPTIMIZATION

As the M2M communications are quite varied, the needed optimizations can be contradictory. 3GPP has identified few major types of optimizations that may be needed for different M2M applications.

Optimization	Functionalities of devices	Example
Low Mobility	move infrequently and do not require the robust mobility management present in cellular systems	fixed vending machines
Time Controlled	scheduled communications	telemetry devices with upload schedule
Small Data Transmissions	need to send only small amounts of data	medical monitoring devices
Infrequent Mobile Terminated	mainly transmit data, but rarely need to receive data	telemetry devices
MTC Monitoring	need to robustly report status changes	alarm systems
Secure Connection	require secure connections	ATMs

However, one of the most important actions is to protect the network itself from overload due to massive numbers of devices that might act in concert.

The diversity of applications is an important factor that makes M2M challenging for operators to address. The M2M application bandwidth and mobility requirements are like:

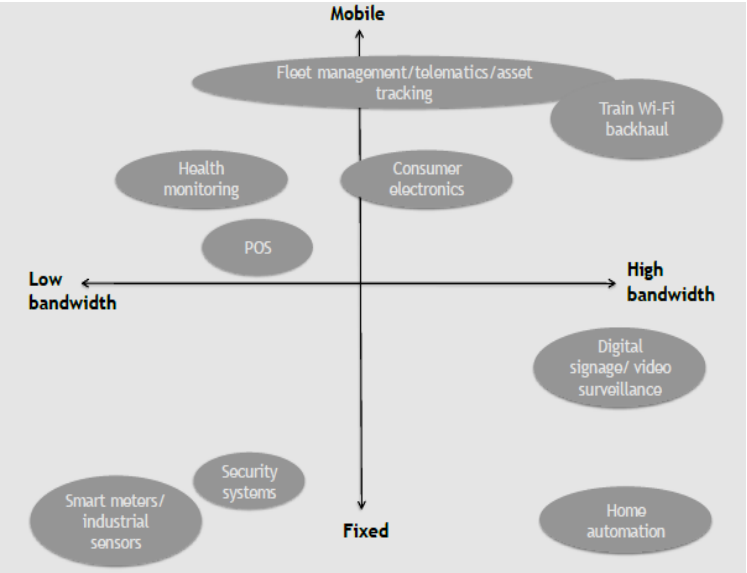

Fig 6: M2M application bandwidth with mobility

VI. MARKET SEGMENT

There are different ways to create market segment for connected devices delivered to people, business and society. The examples of such categories for connected devices are –

Personal communication and infotainment:

- personal communication devices like Mobile phones, laptop computers and Netbooks which are already connected
- personal consumer electronic devices like music players, cameras, etc, which are on the way to be connected

Smart Homes:

- already connected devices like phones, desctop computers
- smart consumer electronic devices include online home entertainment, connected domestic appliances, Utility meters , security cameras etc.

Smart Vehicles:

- Vehicle monitoring, conveniences (auto toll/parking),
- In-vehicle infotainment,
- Remote vehicle diagnostics, fleet management applications, safety/alarm functionality.

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Smart Infrastructures:

- Smart Grid
- Traffic management and control;
- Point of Sale, Vending, Remote Information Displays

Industrial Automation and Monitoring:

Medical Equipment

Tagged Objects:

Containers and moving goods, Positioning and tracking, Asset management and control, Information and identification, Proximity services

Typical M2M Market Segment examples are given below:

M2M Segment	Technology Examples	Application Examples
Cellular M2M	CDMA, GSM/GPRS, EDGE, W-CDMA, LTE	AMI, telematics, remote monitoring, ATM/POS
Wireless Sensor Networking	ZigBee, ISA100.11a, Wireless HART, Wi-Fi	Data center monitoring, building automation, etc.
RFID	LF, HF, UHF, 2.45 GHZ	Asset management, personal & object ID
Building & Industrial Control Systems	4-20 MA, serial bus, Industrial Ethernet, ISA100.11a	Building automation, process automation, factory automation
Home Automation	ZigBee, Z-Wave, PLC, LonWorks ISI, Wi-Fi	Lighting control, energy management
RTLS	Wi-Fi, proprietary SRW	Asset management & tracking

Fig 7: M2M Segment with Technology and Application

VII. M2M PLATFORM AND SOFTWARE PROVIDER

Increasingly complex M2M solutions require much more advanced communication platforms and middleware. To facilitate that, many different types of players are active in this space, ranging from providers of service delivery platforms and middleware to hardware manufacturers and system integrators.

Jasper Wireless is a dedicated provider of M2M service delivery platforms for mobile operators with customers such as AT&T, América Móvil, KPN and Telefónica.

Ericsson entered into the product segment in 2011 when acquiring the M2M platform developed by Telenor Connexion. They have more operator partners on M2M fields like Swisscom, Turkcell etc.

ZTE in China has developed an M2M platform for the domestic market with China Mobile.

Operator Partnership can be segmented on into three, in the value chain breakdown: Connectivity, Device and Modules, Application and system integrations.

For the connectivity partnership, there are three approach to generate revenue from M2M services. These are: Partner at wholesale level, service platform partnership, Operator's own deployment and managing own platform in-house.

Here is the example of some notable operator partnerships with different value chain M2M achievement.

Operator	Partner	Description
Telenor	Ericsson	Ericsson completed the acquisition of Telenor‟s M2M platform in August 2011. Telenor becomes Ericsson‟s client, using the platform for its M2M service. Ericsson will scale the platform and offer it to its huge operator client base.
AT&T	Jasper Wireless	AT&T is the exclusive US partner for Jasper, whose platform enables AT&T to offer flexible billing options to enable device vendors to offer connected services. It also provides activation, provisioning and support to AT&T‟s Emerging Devices business unit.
Orange	Data & Mobile	Orange acquired Data & Mobile in early 2011, an application service provider focused on fleet management solutions that also integrates modules into vehicle-ready devices.
China Mobile	Sierra Wireless	Sierra Wireless has developed a module based on TD-SCDMA technology to enable the operator to offer 3G M2M services.
Verizon	Qualcomm	Joint venture called nPhase, originally acquired by Qualcomm in 2006, set up in 2009. It provides a platform for connecting and managing devices.
T-Mobile	Echelon	Echelon is a leading provider of smart grid products and services to the utilities industry. T-Mobile is providing embedded SIMs for integration into smart meters.

Ericsson, as an example in M2M Platform –

Ericsson, headquartered in Sweden has a global leadership position in the Communication Industry with the portfolio of mobile and fixed network infrastructure, telecom services, software, broadband & multimedia solutions for operators, enterprises and the media industry. Example

In February 2011, Ericsson launched the cloud-based Device Connection Platform (DCP) for mobile operators in wireless M2M market. Based on it, Ericsson acquired Telenor

ISBN: 978-81-923777-9-7

Connexion's M2M technology platform to form one of the core elements of the DCP. The Ericsson DCP comprises two core components – device connectivity services (DCS) and business support services (BSS). The DCS component is based on the M2M networking platform acquired from Telenor Connexion, while the BSS component has mainly been developed by Ericsson. It enables mobile operators to offer their M2M customers a self-service interface, flexible billing, charging and connectivity plans for all devices connected to the network.

Ericsson's M2M-related business activities also include consulting services, system integration and industry-specific solutions based on which Swisscom, Turkcell, Hydro-Québec signed up with Ericsson's M2M platform.

VIII. CONCLUSION

The M2M market opportunity is large enough to create an independent technology vertical in the organisation aligned with the M2M offerings and opportunities.

The M2M related Product Engineering portfolio offers Development, Product lifecycle management, Technology transformation, Network Services and Testing, OSS/BSS Integration across the following technology nodes, complimenting the niche technology skills necessary for the M2M business.

M2M market has huge growth in coming future, hence it is high focus area to partners and operators to act a major role play to get a leading position in the market.

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ISBN: 978-81-923777-9-7