

Costs and risks of wide area M2M application implementations

When starting the implementation of M2M applications, a reasonable number of cost factors and risks are not considered. People are blinded by the dazzling, ideal world of M2M. Unfortunately many projects end up in budget overrun, unsatisfying functionality and poor acceptance by customers and end-users. At the end of the day, and after spending much more money as originally planned, everybody involved is happy that at least "something" is working.

The intended audience are managers, project officers and decision makers who plan or already started to

- operate,
- order,
- develop an M2M application.

The paper is also of interest for system houses and their customer's internal IT and software programming departments confronted with this issue.

The paper shows that M2M projects need not to end-up in a debacle. Costs and risks are foresee- and predictable. Especially hidden factors, mostly not considered, are pointed out. The paper will give a guidance to identify important decision factors for the procurement and implementation of M2M applications.

presented by
www.microtronics.at



presented at
WIRELESS CONGRESS 2009
Oct. 21-22 2009 Munich
www.wireless-congress.com



TOC

Introduction.....	4
What does “wide area M2M” stand for?.....	4
What’s the typical application we are talking about?	4
Which system design to use?	5
Why using GSM cellular networks?	6
Combined technologies	6
Who is involved in a typical M2M project?	7
Customer	7
Application provider (system integrator)	7
Others	7
Goals of involved parties.....	7
Customer	8
Application providers (system integrator)	8
 Cost & risk factors - Definitions	 9
One-off costs - Development	9
One-off costs - Initial setup	9
One-off costs - Roll out per device.....	10
Running costs - maintenance, service, warranty	10
Running costs - infrastructure	11
Running costs - users	11
 Decisions - Overview	 12
What are the general application parameters?	12
Important points about device’s usability	14
Important points about the user interface	16
 Decisions - The cellular network	 18
Why to use a SIM chip instead of a SIM card?	18
Which GSM provider is the best?	19
Do I need “fixed IP”?	22
 Decisions - The development framework	 23
Which communication protocols to use on IP over GSM?	23
Overview of typical protocols	23
Which hardware to choose?	26
Which software to choose?	27
Server-side data management and presentation.....	29
Do I need firmware update over the air (OTA)?	30
Do I need regular update of the server?	31
 Epilogue	 32

Isn't it a risk to depend on a single supplier?	32
The author	32
Appendix A - Helpful Features to think about	33
System wide	33
Device	34
User interface, Server	34
Communications	35

Introduction

Some of the information in this paper represents the personal opinion of its author, based on real-life experience aloof from marketing hypes.

What does “wide area M2M” stand for?

The basic meaning of “M2M”, also known as “internet of things”, is quite clear: *automatic information exchange from machine to machine*. Without any further limitation.

The “wide area” stands for communication distances similar to a MAN or larger. According to IEEE 802-2001 this means at least an area of “...a larger geographical area than a LAN, ranging from several blocks of buildings to entire cities”¹. The area covered by a WAN is included, too: „...covers a broad area i.e. whose communications links cross metropolitan, regional, or national boundaries”².

What’s the typical application we are talking about?

Due to its flexibility, a wide range of applications can be addressed. From automatic meter reading to environmental monitoring, from vehicle/container/asset tracking to flooding surveillance, from vending machines to smart grids, and many more.

All of these applications have some core requirements in common:

- **Large number (typ. 1.000 to >1.000.000) of remote devices**
- **Low data volume of typ. 100kByte to 10MByte per month and device**
- Mainly monitoring and registering few parameters (1 to 100) at moderate recording rates of 1 to 60min
- Alarm features, system health supervision (communication, devices, servers)
- Autonomous local control (with remote parameterization)

¹ IEEE 802-2001 <http://grouper.ieee.org/groups/802/>

² http://en.wikipedia.org/wiki/Wide_area_network

- Parameters remotely changed from time to time (no real-time remote control)
- Devices have a dynamic behaviour³
- Central user interface giving easy remote access to all devices
- No direct device to device communication required, only device ↔ server
- Long term over-all system stability

Which system design to use?

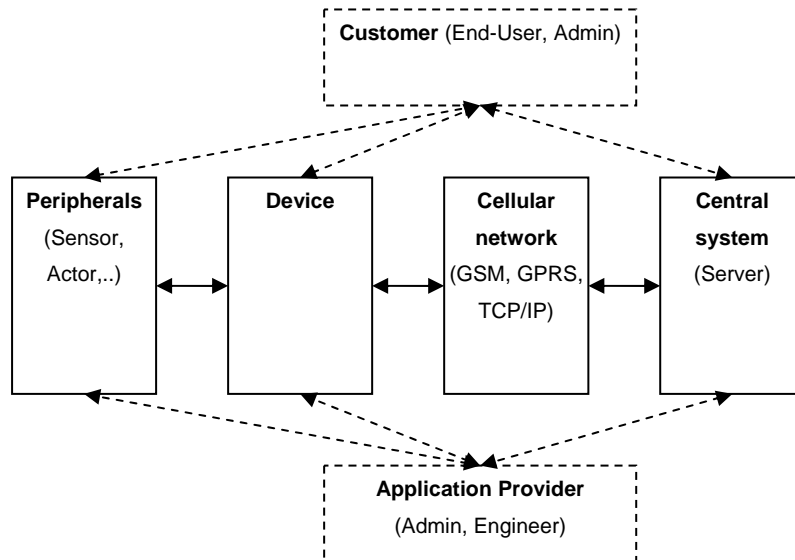
There are many different understandings how an M2M system may look like. They mainly differ in their architecture as well as communication technology.

From loosely organised, distributed units to strongly organised central systems. From the early, so-called 'telecontrol', using fixed landline and analogue modems to wireless systems based on GSM cell networks or even satellite communications.

The field is much too wide to cover it in just a single article, so we have to focus on a single approach. I choose one of the *most fascinating, upcoming system designs*:

- Intelligent (mostly autonomous) devices, controlled by a
- Central system, connected through
- Cellular network

³ Individual devices are added to or removed from the system frequently without significant impact on the system as a whole. The number of devices is typically growing over the years.



Why using GSM cellular networks?

Saves expensive installation and operation efforts for communications infrastructure

Using a single, reliable base-technology saves installation and operation costs ...

- Less skills for operation and launch required (simplifies staff training)
- Small spare part storage

Well known standard technology

GSM, SMS, GPRS, HSCSD, EDGE, UMTS, HSDPA, ...
450, 850, 900, 1800, 1900, 2100 MHz

Excellent coverage ...

- ... Worldwide available, even in many unpopulated areas
- ... Mostly covered by multiple providers, "choose the best" (local roaming) possible

Provides packet oriented data services "by nature" (IP is integrated, but not an add-on)

Billing is based on the data volume rather than on the time connected

Combined technologies

To improve the connection reliability, sometimes technologies may be combined in a device. For example:

- **Satellite + GSM/GPRS** ... ideal for global mobile applications
- **Wired (PSTN,..) + GSM/GPRS** ... for redundant links

But combining multiple technologies has several bottle-necks:

- increased costs for devices

- higher costs for put into operation (at least 2 lines have to be procured and configured)
- higher costs for operation because at least two different infrastructures have to be paid
- mobility decreases due to increased device size and shorter battery life

Who is involved in a typical M2M project?

The main players are the

- Customer and the
- Application provider (which usually acts as system integrator)

Customer

...uses the application for his daily business

- Operators ... using the application for their daily business
- Administrators ... coordinate the system operation, manage end-users,...
- Maintenance ... care about the technical system infrastructure

Application provider (system integrator)

... develops, operates and maintains the application

- Administrator ... manages customers
- Maintenance ... care about the technical system infrastructure
- Application programming
 - Device firmware
 - Server software, Userinterface
 - Interfaces for Customers IT Systems (CRM, Billing, ...)

Others

Of course, there are also a lot of (module) suppliers to think about, but they have no direct impact on the M2M project.

- Device hardware (integrated/OEM electronics, modules)
- Device firmware
- Communications middleware
- GSM provider - mobile communication infrastructure
- Server hardware
- Server software (operating system, database, http server,...)
- Server infrastructure (uplink, network, firewall, housing,...)

Goals of involved parties...

Beside of the natural goal of each corporation - "take some profit from the project and earn money" - the requirements of the Customers are the driving factor for M2M projects. *Mostly the risky part is outsourced to the Application provider*, who has to fulfil the Customers requirements within limited time- and budgetary resources (tender).

Customer

- Monetary benefits
 - Maximise the gain resulting from Benefits minus TCO
 - Save travelling costs
 - Increased sales of his core competence/product
(preventive re-filling of tanks, vending machines)
 - Lowest possible TCO
- Improved information quality
 - Timely accurate information (information at the finger tip)
 - Graphics showing trends
 - Easy distribution of information to a larger audience (public information systems)
- Social acceptance - easy handling
- Simple integration into existing systems (CRM, Billing, ...)

Users expect at least the comfort of mobile telephony - turn the thing on and it is connected.

Application providers (system integrator)

- Prediction of costs and timeline as exact as possible (for development & operation)
- Minimisation of costs
 - one-off costs - development, launch, ...
 - running costs - usability, down times, hardware failures, ...
- Risk minimisation (costs, time line, functions)
- Time to market as quick as possible
- Maximum functionality (firmware OTA, GSM tracking, surveillance features...)

Cost & risk factors - Definitions

This is not a TCO calculation, only some important factors of the TCO are considered!

For further analysis the cost & risk factors (CRF) are grouped into 6 main categories:

One-off costs



Development



Initial setup



Roll out per device

Running costs



**Maintenance, service,
warranty**



Infrastructure



Users

There is no further breakdown, because at the end of the day all of them end up in single one → the commercial costs & risks.

One-off costs - Development



- **Missing the timeline, delayed launch** ... endows competitors with market shares; *Time = market share = money*; A penalty clause may hit the system integrator.
- **Increasing development costs** ... lead to additional investments to achieve the aim and unpaid efforts
- **Missing the requirements, especially the performance demands** ... result in additional investments and/or insufficient system behaviour

One-off costs - Initial setup



- **Installation of central system** and user interface
- **Central hardware** and network infrastructure
- **Software licences**

One-off costs - Roll out per device

Sum of efforts required to put a *single* device into operation - *these costs scale by number of devices!*



- **Procure SIM card** and required access codes
- **Organize the infrastructure** (power supply, keys for rooms/cabinets)
- Local setup and **mounting of the device**
- **Setup a device on the system**
- **Production costs** per device

Running costs - maintenance, service, warranty



- **Maintainability** ... Efforts necessary to maintain the system over it's lifetime.
Due to close time schedules and complexity of the systems/applications, there is never a 100% test possible. M2M applications usually undergo later-on
 - Bugfixing
 - Improvement, functional extensions
 - Adaption to new technologies
 - Automatic updates of servers and devices (OTA)
- **Service of devices** ... easy exchange of devices without programming work and data-loss is especially important if devices need regular calibration
- **Long-term reliability of hardware** ... brand-new hardware which is not tested in the field over years is subject to an increased number of warranty claims.
- **Reliability of software** ... the more application specific software inside, the higher the risk of software bugs. Well proven middleware reduce this

risk.

- **Server maintenance**

Running costs - infrastructure



- **Device/Server communication**
- **Server infrastructure** and communication

Running costs - users



- **Usability, acceptance** ... Efforts for user training and hotline support
- **Risk of mal-operation** ... Higher required skills result in higher costs for trainings and increased potential for mal-operation by the Users.
- **End-User skills** & training costs ... Skills required for everyday handling such as data retrieval
- **Administrator skills** & training costs ... Skills required for system handling such as put into operation of devices and regular maintenance work.

Decisions - Overview

..and their influence on cost & risk factors.

Even when focusing on GSM based M2M applications only, you can find a wide field of traps, risks and hidden cost drivers. To give a better orientation, the large field is broken down into a loose list of important (from the author's point of view) decisions you have to make.

On each decision some of its consequences are described, and the influence on the overall-project is stated with red and green dots. A red dot marks decisions that increase risks and/or costs (negative influence). A green dot marks the contrary behaviour. No mark stands for "no significant influence".

What are the general application parameters?


Get a clear idea where to go to and which system constraints you may accept. Define the absolute maximum limits you may need - even if they seem to be far away.





Consider that M2M applications always


- grow over the years, there is never just a one-time rollout
- undergo an continuous application improvement and extension


To do performance optimization later-on increases costs dramatically, or may be even impossible. Keep in mind, if the solution is able to grow with your business.

Scalability and performance are a big issue already during the requirements analysis.

Decision	Description	Effect
Multi- or single-purpose application?	Will you run just a single type of application? Or may you wish to add additional applications (e.g. metering and plant health monitoring) on the same system.	Using a single M2M system for multiple applications gives a homogenous, cost saving environment.
	Will you connect different types of devices (with different functionality) to your system?	

<p>Install the application server multiple times?</p>	<p>Do you plan to distribute the application server, for example as an individual copy for each customer?</p> <p>Does the customer need absolute privacy for his data on a physical basis?</p>	<p>Easily distributable servers guarantee</p> <ul style="list-style-type: none"> - absolute privacy for customers' data - improved performance at low efforts.
		
<p>Number of devices?</p> <p>Recording and Transmission interval?</p>	<p>What will be the absolute maximum load for the server?</p>	<p>Systems which can not demonstrate sufficient performance <u>in advance</u> are of high risk to fail later-on.</p>
		
<p>Amount of data to store?</p> <p>Periods to retrieve?</p>	<p>Amount of data depends on</p> <ul style="list-style-type: none"> - recording interval - number of devices - number of channels per device - storage depth (many years) 	<p>Systems should demonstrate from the beginning that they are able to retrieve huge amount of data (charts, tables) just in time.</p>
		
<p>Number of concurrent users?</p>	<p>M2M applications usually have hundreds (or even thousands) of users. But not all of them act at the same time.</p>	<p>Systems should demonstrate that they are able to handle the users based on their typical actions (view a chart, change some settings, ...).</p>
		

<p>Geographic area to be covered by the user interface?</p>	<p>M2M applications are very often used by persons from several countries.</p>	<p>For international users, the M2M system must support</p> <ul style="list-style-type: none"> - multiple languages - multiple time-zones with individual daylight saving - different number and date/time formats
<p>International, multi-language user-interface required?</p>	<p>The user in Florida may need to see the measurement data from the device installed in Italy in his personal time zone.</p>	

<p>Geographic area to be covered by devices?</p>	<p>M2M systems are typically geographically unbounded, devices are scattered even worldwide.</p> <ul style="list-style-type: none"> - Just a single country? - A certain list of countries? - A region such like Europe? - Worldwide? 	<p>This will effect the selection of GSM provider and tariffs, as well as efforts for implementing handling algorithms.</p> <p>Furthermore each country may have its own regulations to be fulfilled by the device hardware. Certain certifications (CE, FCC,...) are required.</p>
		

Important points about device's usability

Decision	Description	Effect
<p>Mobility of device?</p>	<p>Is the device mounted on a mobile object such as a container or vehicle?</p>	<p>Compact shape, light weight and 100% wireless operation (battery driven) are helpful.</p>
	<p>Is the device moved frequently?</p>	<p>Ultra low power consumption is mandatory for mobile devices to achieve run-times of several months or years.</p>



<p>Portability of device?</p>	<p>Do you need to collect the device from time to time for re-calibration and regular maintenance work?</p> <p>Data shall remain even after changing the device. Some kind of “virtual site” with easy way to change the device is required.</p>	<p>It is of advantage if exchanging devices can be done easily without complicate programming work. This enables the end-user to execute the job without intervention of administrators and system programmers.</p>
<p>Shall end-users without deep technical knowledge install devices?</p>	<p>M2M applications are typically distributed over large areas. Therefore it's expensive to bring a trained technician to each site.</p> <p>But typical end-users like salesmen are often on-site. It's great if they are enabled to install devices on their own.</p>	<p>Less efforts for travelling (technician), simplified user interface, better acceptance</p>
<p>Power supply for devices?</p>	<p>Several important supply concepts are available:</p> <ul style="list-style-type: none"> - Line powered - [chargeable] Battery only - Solar, energy harvesting 	<p>“Line-powered” needs at least a power cable on-site.</p> <p>“Battery-only” is the most comfortable way for the end-user, but it requires special attention on power efficiency (communications, application,...).</p> <p>“Solar” may help if Battery-only is not sufficient (and power line is not available). Other types of energy harvesting are upcoming but very often</p>



too expensive.



Special certificates such as ATEX required?	Are the devices used under extreme conditions, where additional certificates are required?	Getting the certificates costs money and much more time. Product launch may be delayed due to unpredictable behaviour of the certification authority. Production costs may increase due to unforeseen requirements.

Important points about the user interface

Decision	Description	Effect
Which web-browser to support?	In most cases it is not acceptable to limit the application to a certain web-browser or operating system.	Using pure web-browsers, with HTML and Java-Script only guarantees full user interaction on any kind of web-browser without
Support for smart phones?	<p>Only M2M systems which are independent of operating system and web-browser brand are acceptable.</p> <p>Another no-no are technologies where the end-user has to install special software (plug-in) like ActiveX controls, Flash player, Silverlight client,...</p>	<p>- additional installations causing problems (user needs the right to install..)</p> <p>- long waiting times for loading frameworks</p>
Is WAP required?	In certain cases WAP may be	Some additional programming for

helpful, but functionality of the user-interface is very limited.

The upcoming wide range of smart phones will supersede the WAP technology in the near future.

separate WAP pages is necessary.

On some applications, providing smart phones to the end-users may be more advantageous than investing in a special WAP interface.



Is the application used just in a single country or even world wide?

When operating in a global context, it's important to offer localisation features to the user:

- Language
- Time zone (incl. individual daylight saving)
- Number and date/time formats

Time zone selection is required per user and per site.

Implementing flexible handling of time zones (and daylight saving) is much more complex as it sounds.



Decisions - The cellular network



Why to use a SIM chip instead of a SIM card?

The (pluggable) SIM card offers freedom to the end-user to select the GSM provider anytime. So he may change the SIM provider after some years of operation if he finds a cheaper one.

On the other hand, the end-user has to purchase an adequate SIM, get the required settings and codes, and install it. A lot of traps are waiting for an average consumer, not all know terms like GPRS, EDGE, UMTS, APN, ... And the efforts for changing the SIM after some years of operation will consume a significant part of savings borne by a cheaper tariff.

Under extreme environmental conditions the mechanics of the SIM slot are subject to deformation by temperature, oxidation of contacts by moisture and loss of contact due to dust. Even if the device is rugged this may happen when the end-user accesses the SIM slot.

Using a pre-installed SIM-chip takes away all burdens from the end-user.

SIM card	+ freedom to choose anytime	
(pluggable)		
SIM chip	+ zero installation effort for the end-user, turn on and work	
(preinstalled)	+ less skills and training required	
	+ stable even under extreme environmental conditions, minimise probability of damage	
	+ allows for more robust design of mechanics and electronics	

Note: So called “zero base rate, but minimum usage” tariffs are equally worse.

Price per MByte transmitted	<p>The price may vary depending on location of the device (→ International roaming).</p> <p>Since M2M applications typically generate very low data volumes (100kByte to 10Mbyte per month), this parameter may be much more expensive as known from mainstream internet applications (below €0,01 per MByte).</p> <p>If the GSM provider insists in a → monthly base rate, there should be at least a data volume pool across all SIM's. If a single SIM transfers too much data, this can be usually compensated by other SIM's which do not reach the limit.</p>	<p>depends on roaming and base rate options</p> <p>10,- per MByte (for global usage) is already quite expensive anyway</p>
<p>Be aware of → Packet rounding</p>		
Packet rounding	<p>Many devices drop the GSM connection after transmitting data to safe power (especially battery driven ones).</p> <p>In this case, GSM providers invoice for a minimum quantity of data per connection. This should be not more than 1kByte, but may be up to 100kByte(!).</p> <p>Be careful if the minimum packet size is calculated for up- and downstream in total or individually (this may double the minimum packet size).</p>	<p>max. 1kByte per direction</p>
International roaming	<p>The devices of an M2M application typically move around in a certain area. This may be just a single country (you lucky one), a group of countries or whole continent, or even world wide.</p>	<p>single tariff for the whole area where your devices are installed</p>
EU is NOT Europe	<p>If operation is limited to a single country → National roaming may be of interest.</p> <p>If you have to cover a group of countries or a whole continent, be aware of the poor geographic</p>	

understanding of GSM provider.

“Our tariff covers countries of the European continent” does *not mean* “*all the continent*” is covered, and

“Countries of the European Union (EU)” for example do *exclude Switzerland and Norway!*

Anyway - as soon as you need roaming you should have a single tariff for the whole area where your devices may be used. Otherwise you will be not able to check invoicing of SIM's anymore.

National roaming	When you operate in rural areas with poor GSM coverage, it is mission critical to select from multiple GSM providers. To keep installation costs low, this task has to be done automatically by the device up on runtime.	mission critical for rural area applications
-------------------------	---	--

International roaming solves this if your devices are “abroad”. But inside the home country of your GSM provider you usually stick to him and can not use other ones, even if he has no coverage at a certain location (and there is always one).

If your GSM provider states “This feature is not available.” - do not believe. He just means *that he is not able, or not willing*, to sell it to you. Perhaps you may have to change the GSM provider.

Interface for SIM provisioning and billing	Does the GSM provider supply interfaces to - activate and de-activate SIM's - run cost-control (check monthly data volume)	access through web-frontend and electronic interface (XML)
	For small systems with some dozens of devices a web-interface may be sufficient.	
	But typical M2M applications need automatic routines deeply integrated into the M2M application to run these tasks. Therefore an electronic interface (XML or similar) is required.	
	How accurate is the data volume indication? Especially on roaming SIM's there might be a	max. 24hrs delay for data volume

	delay of several hours.	indication
Binding period	<p>The goal of a GSM provider is to bind you as long as possible. In M2M applications binding periods of several years are normally no problem, since the SIM card (or chip) will stick in the device for many years. But always consider</p> <p>→ Reliability / Test before binding period and</p> <p>→ Monthly base rate per SIM</p>	<p>Up to 5 years on SIM cards</p> <p>Up to 10 years on SIM chips</p>
Reliability	<p>Check out if the marketing promises are adhered in real life.</p> <p><i>A good provider will agree to a test period of several months, without any obligations. Be aware of providers who want to sell a contract (with minimum binding period) only.</i></p>	<p>Test period of 6 months</p>

Do I need “fixed IP”?

It depends on your application architecture.

Fixed IP The “fixed IP” is usually charged as an extra service.

Most modern applications *do not need it*.

Nevertheless there are many providers on the market who would like to sell it to you.



Decisions - The development framework

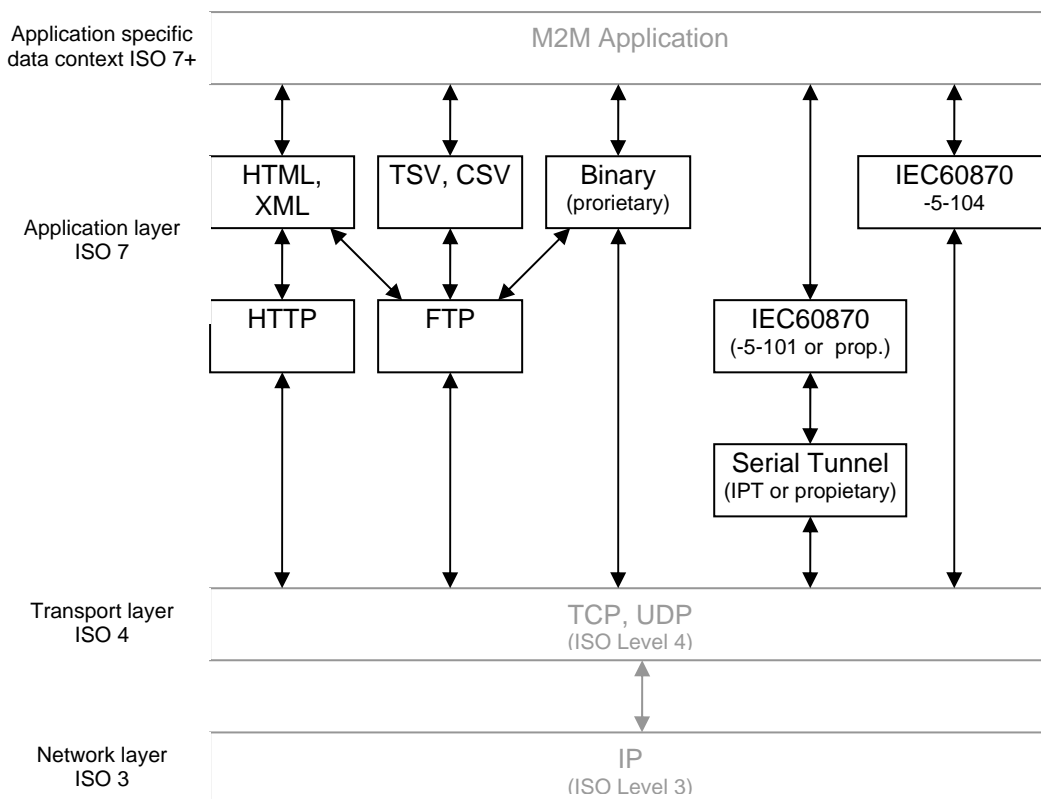
Which communication protocols to use on IP over GSM?

Connections over a GSM network are often subject to poor radio signal strength (rssi) or jamming. They end up in interruption of the GSM connection.

A good protocol should minimize the data volume over the air to

- keep communication costs low
- save energy
- reduce probability of interruption

Overview of typical protocols



IEC60870-5-104	<ul style="list-style-type: none"> + Supports the whole implementation stack + Great flexibility for a wide range of telemetry applications - Designed for telemetry control over wired connections, generates high data volumes (typ. 400kByte per day when idle) - Not designed for high number of line interruptions and low bandwidth connections - Very complicate programming and setup due to universal approach
-----------------------	--

IEC60870-5-101 over serial tunnel	<ul style="list-style-type: none"> - Out of date, long-winded solution, replaced by -104 - Serial tunnel is very often based on proprietary protocols, at least it does not offer standardisation on application level
--	--

Proprietary protocol over serial tunnel	<ul style="list-style-type: none"> - Heavy problems with interruptions - Server becomes often instable when connecting several dozens of devices using virtual com ports - Usually blows up data volume due to unnecessary communication cycles + Easy way to implement for people not familiar with internet communication technologies (e.g. automation industries, PLC programmers) - Serial tunnel is very often based on proprietary protocols, at least it does not offer standardisation on application level
--	---

FTP	<ul style="list-style-type: none"> + Standard mechanism for exchange of complete files
with HTML, XML, TSV or CSV on it	<ul style="list-style-type: none"> + Resume after interrupted connection is built in for download... - .. but workaround for upload required - Insufficient built-in intelligence (re-sync after interruption, prioritisation, transaction control over multiple files...) - No intelligent re-synchronisation of contents built in

-
- ASCII text coding blows up data volume by typ. >200% on TSV/CSV or even >500% on HTML/XML coding
 - + Coding is proprietary, but at least readable by human (mostly of interest during development)
-

FTP same as above, but

- with binary
encoded files on it
- o data volume is blown up only a little bit by FTP protocol overhead (typ. <50%, depending on user data stored in the files)
 - Files are not readable by human anymore
 - File coding is proprietary
-

HTTP

with HTML or XML
on it

- Blows up data volume by typ. >500% because of ASCII text transmission with additional tags
 - No built-in intelligence (re-sync after interruption, prioritisation, ...)
 - High resource demand (processing load) on server limits number of devices and/or transmission intervals
 - + Readable by human to check communications (only of interest during development)
-

Binary only

Proprietary “all in
one” protocols

- + Combine application context, data coding and transmission protocol in the most efficient way
 - + Typically binary coded (reduces data volume, transmission times and power consumption)
 - + Built-in intelligence for bi-directional synchronisation, re-sync after interruption, prioritisation of information) with minimum overhead
 - + Compatible with high performance database on a binary basis (!) dramatically reduces demands on the server
 - + Very robust even on low radio signal strength
 - Only readable using special debugging tools (sniffer applications)
-

- All levels are proprietary

Standard protocols easy to implement and applicable for all kind of M2M applications will be hard to create.

Which hardware to choose?

On the server side, the answer seems to be clear. Nobody should think about to design his own server hardware. Only branded products of excellent quality are acceptable.

For the device are several typical options available:

- **PLC + Modem:** Use a ready made PLC and combine it with a ready-made modem.
- **Intelligent OEM module:** Combine some ready made OEM electronics with your own hardware design.
- **Ready-Made OEM device:** Use ready made OEM electronics and casing.
- **Self-made:** Design your own device from the scratch. Freely programmable, ready-made communication modules are available for acceptable prices.

PLC + Modem



- + No costs and risks on hardware design
- Shape, power consumption
- Unacceptable production costs for systems with high number of devices
- Less functionality, put into operation is more complicate



Intelligent OEM module

- + Medium costs and low risks on hardware design (typically limited to trivial IO signal conversion and power supply)
- + Low production costs from small up to large scale systems
- + High flexibility
- Certifications (CE,FCC,...) required
- Dependency on module supplier



<p>Ready-Made OEM device</p>	<ul style="list-style-type: none"> + No costs and risks on hardware design + Acceptable shape, low power consumption +/- Production costs are very low for small scale systems, only on large systems there might be some reasonable disadvantage - Limited flexibility or external initial costs when hardware has to be customised to your specific requirements - Dependency on hardware supplier 	
<p>Self-made</p>	<ul style="list-style-type: none"> + Unique design + Compact shape, optimal hardware integration - Very high risk and development costs - Certifications (CE,FCC,...) required +/- Production costs may be reduced a bit, but only on huge quantities 	

Which software to choose?

The selection of the development process is driven by available budgets, time-line and the feature-set required.

The typical situation:

- Customer and application provider have a deep understanding of the application - it's their core business.
- There are no resources and no budgets to develop or maintain basic technologies
- The time-line is tight

Typical approaches:

Self-made integrated solution: All software components are designed in-house. Even web-server and database software is integrated into the application software. This results in a compact, high efficient software, but implies very high efforts and risks.

Self-made solution based on main-stream products: Only the application specific software is designed in-house. All other software elements are taken individually off-the-shelf. This reduces development efforts, but brings more complexity for the initial system setup. Distribution of the server gets more complicated and integration of multiple 3rd party products is necessary.

Using a ready-made specialized communication stack: GSM based communication brings a lot of adventures. A ready-made communication stack can hide the complexity of communications. Application programming gets easy if the stack offers a “storage to storage” operation. In this case the application is treated as a big, distributed database, where you can control the synchronisation mechanisms without the burden of communication details. This may be combined with any “Self-made” solution.

Ready made integrated solution: The most comfortable way. All basic technology - *communication stack, database, web-server,...* - is taken off-the-shelf as *a single integrated packet*. The application provider can concentrate on his core business - the application itself. This guarantees a high performance solution, low initial costs, low risk and regular maintenance at low rates.

Self-made integrated solution



- + No external costs
- + High performance
- High risks and efforts from the beginning
- Only recommendable for professional solutions if there are enough resources/budgets to maintain the solution over many years



Self-made based on main-stream products

- + Possibly lower initial costs for very simple systems
- Many freeware components have to be paid when used in commercial systems
- High risks and efforts on the long run when system complexity increases
- High demands in server hardware, lack in performance




<p>Using a ready made, specialized communication stack</p>	<ul style="list-style-type: none"> + Improves self-made solutions + Saves costs and risk during development + Storage to storage approach minimises cost, risk and time to market - External costs, licence fees 	
<p>Ready made integrated solution</p>	<ul style="list-style-type: none"> + Easiest way to setup the M2M application + Quick, foreseeable costs and time-line + Strictly optimized performance, lowest possible hardware requirements - External costs, licence fees + Continuous improvement and adaptation to new technologies for low rates 	


The application provider can focus on his core business only, when using 3rd party solutions as enabling technology. Nobody who needs a hammer will build one - he will buy it and do his job.

Server-side data management and presentation

M2M applications typically generate huge amount of data.

If 1000 devices record data at an interval of 1 minute you may get more than 13 gigabyte of data per year (at 25 byte per recording). Users often need to fetch information over long periods of several months, or even years. To grant acceptable access times, you have only two options:

<p>build summarized data (e.g. on weekly basis) and store it in extra space</p>	<ul style="list-style-type: none"> - high development and implementation efforts - problems with delayed data - inflexible structures + can be built based on standard tools 	
--	--	---

use high speed data cores with built in just-in-time processing	<ul style="list-style-type: none"> - requires non-standard tools + very flexible for extensions + no problems with delayed data 	
--	--	---

Do I need firmware update over the air (OTA)?



Firmware updates are typically necessary to

- fix a bug
- expand functionality of devices
- adapt to new technologies or improve the device's behaviour

The roll-out of firmware updates shall be fully automatic, based on rules limiting the update to certain

- devices (serial number)
- type of devices
- firmware versions...

Execution of the update must be kept under surveillance and any problems have to be reported to the administrator.

none	<ul style="list-style-type: none"> + no development and initial setup costs - devices must be brought to the service center to apply new firmware 	
external update service	<ul style="list-style-type: none"> + comfortable solution for the user - needs some coding for integration into the device - no single point of service (update runs on one platform, device management runs on another) - extra costs - security risks because binary files have to be given to an external service provider 	

- fully integrated update service**
- + most comfortable solution for the user and programmer
 - + single point of service: success of update can be checked via the well-known system platform; events are reported via well known methods
 - + can support multiple controllers per device
 - + very low implementation efforts when using a ready-made integrated system software
 - + usually no extra costs, it's all integrated



Do I need regular update of the server?

Definitely yes. There remains just the question - manual or automatic?

Server updates are typically necessary to

- adapt to new technologies such as new web-browsers
- expand functionality
- integrate new devices
- fix a bug

- none (manual)**
- + no development and initial setup costs
 - manual efforts on each update only acceptable for very low number of servers



- with automatic update**
- + comfortable solution for high number of distributed servers
 - + built-in (free of charge) function on ready-made integrated system software



Epilogue

Isn't it a risk to depend on a single supplier?

Due to missing practicable standardisation, many solution providers compete on the market with non-interoperable solutions. They all use the same buzzwords such as XML, FTP, HTTP, JAVA, AJAX, Web2.0 ... suggesting independence for the customer.

But you can be sure - you will stick to them forever.

But...

Do you use Windows? Or Microsoft Office™? Have you ever read a PDF™ document? Are you sure your homepage has no Flash™ content?

Well - we always depend on single suppliers when we use valuable up-to-date technology. **The important question is, if we get enough value for what we pay for.**

Choose either well working high performance solutions with clear responsibilities, or very open solutions with often poor performance and where nobody is responsible for. The worst thing we can do is to develop the wheel each time from the bottom. Limited project budgets lead to poor functionality, low scalability and high risks for all involved parties.

In fact: ***you always depend on suppliers in the same way as they depend on you.***

The author

Andreas Aigelsreiter is CTO at Microtronics Engineering GmbH and senior system architect of www.mydatanet.at which has been borne after 5 years of intensive application engineering together with customers product managers and end-users. His application knowledge is backed by a wide range of already realised M2M applications, as well as 20 years of experience in M2M core technologies such as GSM/GPRS, IP based communication, web-platform programming and high performance database architectures.

Appendix A - Helpful Features to think about

This is just an excerpt of some important features.

System wide

flexibility	<p>support for multiple types of devices and applications</p> <p>single point of configuration at the central system (compact definition of data structure and user interfaces)</p> <p>customisation of user interface and data structures shall not exclude further server updates</p>
time synchronisation	<p>time base, time zone, daylight saving</p> <p>fully automatic system-wide synchronisation (no dependency on GSM time service)</p>
firmware update over the air	<p>new firmware is installed either at a central server or at the customer's server; fully automatic download to all devices with supervision and fault alarm; the firmware package may include:</p> <ul style="list-style-type: none"> - operating system - middleware - application software - sub-controller software
configuration management	<p>context sensible, fully automatic bidirectional synchronisation between the node and its server</p>
GSM based tracking service	<p>GPS is not always available and brings additional costs.</p> <p>In many cases it's practicable to get just an idea of the devices position. GSM triangulation can solve this.</p>

intelligent data management	<p>must be failsafe and automatically recover without extra data volumes on instable connections</p> <p>storage to storage middleware solutions offer an easy way of system integration</p>
------------------------------------	---

Device

supervision of unattended operation	100% supervision of device operation (device status, connection status, firmware updates, sensor health, notification handling..) to guarantee fully unattended operation
life cycle management	supervision of the nodes product life cycle, incl. production and maintenance events; built-in support ticket system
power management	<p>on mobile devices it's of utmost importance to achieve</p> <ul style="list-style-type: none"> - long battery runtimes at - small (handy) shapes and - low weight.
USB interface	<p>A M2M device <i>is not a modem!</i></p> <p>Customisation of USB drivers is necessary.</p>

User interface, Server

localisation	fully automatic handling of server / context / user specific localisation information such as number format, date/time formats, languages, time zone, daylight saving...
data management	context sensible, fully automatic upload of node's measurement data to it's server, unlimited storage duration (depth)
location tracking	GPS and GSM tracking incl. GSM to geo coordinates conversion
alarm management	ready made mechanisms for alarming from the node upwards to the user interface
user management	user groups and rights management

device management	list all devices actually not in use, assign devices to sites
SIM management	acquisition and supervision of transmitted data volumes; charging system for prepaid SIM
IP management	backward decoding of dynamic node IP's; no static IP's required! centralized node status list (online, offline)
comfortable data retrieval for the user	Interactive, high speed grafics Download of data (TSV, XML,..) Configurable personal views

Communications

SIM technology	Embedded chip or SIM card?
Roaming	Does the tariff cover a whole geographic area or just single countries? What about national roaming?
Data volumes	How much data volume is generated? How much overhead? Does the system inform the user if data volume limits exceeded?
Communication surveillance	Does the system inform the user if devices stop from communication?
Experience	Has the system been tested with - all GSM providers in - all countries relevant for the M2M application?