GOVERNMENTS ENABLED WITH IPv6

GEN6

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Abstract:

This deliverable shortly presents the Greek IPv6 pilot in schools and describes the administrative and technical (such as networking, security, data management, etc.) requirements and design principles. The pilot aims to interconnect intelligent smart meters over IPv6 in 50 schools and influence the behaviour of the school communities so as to reduce energy consumption. This pilot may have a significant impact to public sector infrastructures and it will demonstrate how IPv6 may become an enabling technology for new advanced services.

Keywords:

IPv6, IPv6-enabled services, energy awareness, energy smart metering, Greek School Network (GSN), public sector.

Revision History

The following table describes the main changes done in this document since its creation.

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v1.1	22/2/2012	First Draft	E. Varvarigos, K. Koumoutsos, M.Oikonomakos (CTI)
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v1.6	03/04/2012	Final review	Jordi Palet (Consulintel)

Disclaimer

Executive Summary

The Greek IPv6 pilot will make students and educators aware of the energy consumption consequences of their behaviours and of the energy characteristics of the school buildings. Energy related information from participating schools will be recorded using smart meters, stored and processed using scalable cloud computing and disseminated to the users via a secure communication channel.

To achieve these goals, the Greek IPv6 pilot will exploit and augment the existing IPv6 infrastructure of the Greek School Network (GSN), extend the IPv4-only infrastructure of the application domain (smart meters and cloud-based application) so that it becomes IPv6-enabled, and integrate them through a pilot deployment of smart meters in 50 schools. The meters will measure and record the energy consumption of participating schools in real time, in order to raise energy-awareness and motivate behavioural changes in the education community, and also to reduce the actual carbon footprint of the participating schools. This project deliverable presents a report for the requirements of Greek IPv6 Pilot.

The approach used in identifying the administrative and technical requirements is as follow:

- Initially, the criteria to be used in selecting the fifty schools that will participate in the Greek IPv6 Pilot are explained in this deliverable. Two sets of factors are important in choosing an appropriate set of participating schools. The first one is related to the location of the schools and the second one is based on their detailed characteristics. In order to identify a set of candidate schools that will maximize the degree of success and the impact of the project, a survey among the schools has been performed to collect relevant information. The results of the survey will be analysed and will be combined with phone interviews and on-site visits before the final selection is made.

- Secondly, issues related to the networking infrastructure are covered in this deliverable. We describe the network architecture of the Greek Schools Network (GSN) and the IPv6 addressing schema that will be used during the deployment of the IPv6-enabled smart energy devices in the schools. The IPv6 implementation phase is described in detail. Security issues and restrictions that apply to the network are provided. Furthermore, issues related to the privacy of the power consumption data and the monitoring and SLA requirements are described.

- Finally, the deliverable describes system and data management requirements, including requirements on the smart energy connectivity and the cloud based system in which the data from the smart meters will be aggregated.

The technology provided by the pilot will empower public authorities in reducing the energy consumption and carbon emissions of public infrastructures, by raising energy-awareness and providing motivation for the adoption of environmentally friendly behaviours and policies. **It will also be a demonstration of the advantages of public services based on IPv6**.

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1. Introduction

The recent advances in energy metering and energy efficient equipment have been partially adopted in public and residential buildings. Informing the public, and especially the primary and secondary students and their teachers, about energy-efficient behaviour and new energy-related technologies usually requires significant time, effort and resources, possibly more than a typical organisation is willing or able to spare. In addition, the financial gain, i.e. a determinant factor for the adoption of “green” technologies and best practices, is also generally difficult to be accurately estimated and appreciated.

The Greek IPv6 pilot in Schools aims to provide the means to influence the students’ behaviour so as to become more environmental friendly and result in actions that preserve energy resources. In addition, the pilot aims to deploy an intelligent infrastructure across multiple schools to effectively measure the energy consumption in real time and to estimate the financial benefits from the adoption of green technologies. The intelligent infrastructure integrates local sensors, smart power metering sub-systems, information analysis and fusion techniques implemented over the cloud, decision support tools, etc.

The Greek IPv6 pilot in Schools aims to demonstrate that IPv6 may become the leveraging technology for enhancing existing services or providing new services to the end users. In the context of GEN6, this pilot will investigate the benefits of establishing an advanced metering infrastructure over IPv4 and IPv6 and provide insights about the benefits of building IPv6 services.

The Greek IPv6 pilot in Schools is realized or supported by the following public authorities, research organisations and commercial companies:

- The Computer Technology Institute & Press “Diophantus” (CTI), under the supervision of the Minister of Education, Lifelong Learning and Religious Affairs[1], responsible for the administration and the daily operation of the Greek School Network, which provides advanced IT services to the primary and secondary schools in Greece.
- Greek Research & Technology Network[2], under the supervision of the Minister of Education, Lifelong Learning and Religious Affairs[1], responsible for providing networking and cloud computing services to the Greek academic and research communities.
- The Intelen Group, a start-up company providing services to the Energy and ICT sector, such as smart metering, meter data management, etc.

[1] http://www.minedu.gov.gr

[2] http://www.grnet.gr

2. SCHOOL AND ADMINISTRATIVE REQUIREMENTS

The Greek IPv6 pilot aims to demonstrate that IPv6 may become the enabling technology for new services, such as smart energy metering. The pilot includes the installation of IPv6-enabled smart energy meters to fifty (50) public schools in Greece with the parallel upgrade of the existing networking infrastructure aiming to fully support the installation of IPv6 enabled smart meters and the provision of IPv6 services to the GSN's end users. The installed smart energy meters within each school will clearly -in real time- illustrate to the students the correlation between their actions and energy consumption/CO_2 emissions of their schools, providing significant motivation for behavioural changes. Moreover, an IPv6 enabled web based platform will be developed targeting to become an educational and social engagement tool for students. This platform will stimulate discussions and actions within schools related to the energy consumption and its environmental implications.

By enabling IPv6 in the current infrastructure, the provided services reliability will be increased as well as the efficiency for data management and control. The main goal is to reduce the schools' energy bills and carbon footprint by at least 10% and to offer real-time energy efficiency services, over IPv6. Furthermore, the pilot focuses on positively affecting the students' behaviour and raising awareness over IPv6 as well as environmental issues.

An important initial decision that has to be made and will influence the success and the impact of the Greek pilot is the selection of the participating schools. The selection will be done based on the location of the schools and their detailed characteristics:

- **Location of the schools**: It was decided that the selected schools will be located across three adjacent prefectures -named, Achaia, Korinthia and Attiki- within the Greek territory, based on the following facts:

    a) Attiki is the biggest prefecture of Greece in terms of population, in which Athens is also located. Since 20% of Greek schools are located in the prefecture of Attiki, a representative set from this area has been selected. Furthermore, provided that the Ministry of Education decides in the future to extend the metering project to a much wider scale in Greece, the results from the pilot in the Attiki prefecture would be very useful. Schools in Achaia and Korinthia were also selected based on the proximity of these prefectures to Attiki, as well as the existence of the GSN NOC premises in Achaia and thus the capability for on-site provision of technical support when needed. GRNET and Intelen have their main premises or a significant presence, respectively, in the prefecture of Attiki. Thus, the selection of schools in the prefectures of Attiki, Achaia and Korinthia, which are in rather close proximity, will lead to full technical support availability and reliability for the project.

b) The selected prefectures present sufficiently diverse geological and climate conditions. Variations in energy consumption can be monitored without, however, affecting the impact on the achieved energy savings in the pilot, which will be based on a percentage basis. This is very important since students' awareness and motivation will be raised from competition with students from other schools. For competition among schools to be strengthened the results for different schools should be to some extent comparable and the climate conditions should not be radically different.

- **Detailed school characteristics**: GSN interconnects more than 16.000 schools scattered all around Greece. For the selection of the most appropriate schools to participate in the pilot, it is important to obtain information that enables us to estimate and maximize the degree of success and the impact of the project and that will also be useful in the implementation phase. Therefore, CTI organized a survey to take place among the schools. The survey is expected to be completed by the end of March 2012, and will collect information regarding the characteristics of the schools and the school buildings, the student and teacher population and their degree of interest, and existing or past activities on energy efficiency and environmental issues. The survey (in Greek) is available online[3] and collects information regarding important parameters of interest, such as:

    a. The willingness of the school to participate in the pilot.

    b. The existence or lack of broadband connectivity.

    c. The type of the school (primary or secondary education), and the specific grades it includes; students at the last grades of primary education and the first grades of secondary education would be preferable as participants in the pilot activities.

    d. The number of teachers in the school.

    e. The number of students in the school, as it is preferable the participation of schools with a relatively high student population.

    f. The availability or lack of local technical support personnel.

    g. The current or past student activities related to environmental and energy efficiency issues.

[3] http://nts.cti.gr/gen6/limesurvey/index.php?sid=55859&newtest=Y&lang=el

h. The total area (in square meters) of the school premises.

i. The daily electricity load.

j. The power consumption based on the electricity bills.

k. The ease of accessibility of the electrical panel.

l. The proximity of the electrical panel to the school computer room.

m. The number of high consumption (over 500W) energy devices or appliances that is operated at the school.

n. The number of low consumption light bulbs used in the school.

o. Whether single phase or three-phase power supply is available at the school.

p. The existence or lack of a person responsible for environmental activities in the school.

q. The availability of sufficient contact information for the schools.

The previous factors are actually soft requirements to be used for the selection and thus, some of the schools that will finally be selected to participate may not have all the desired characteristics. The final selection of the schools in the pilot will be done based on the analysis of the questionnaire’s responses and some interviews with interested teachers and on-site visits that will be performed. In addition to the above-mentioned factors, the degree of “enthusiasm” and “volunteerism” that will be shown by the students and their instructors will also be significantly considered in addition with the interest on environmental and energy-consumption issues that has been manifested in previous school activities.

The main goal of the survey is to identify the schools whose students and teachers have the most interest for participation, since without student and teacher participation, the impact of the pilot will not be as desired. A secondary goal of the survey is also to collect some initial data that will be useful for further analysis in a later stage, for example to estimate the energy reduction. Finally, focus will also be given on the effectiveness of the dissemination plans that can be carried out within the schools as well as on the possibilities for integration of the pilot installation into their wider environmental activities. The telephone interviews and local visits will be used not only to verify the accuracy of the information collected by the survey but also to estimate the degree of collaboration that will be possible with the local teacher and student population. Finally, during the discussions that will take place with the schools that have expressed an initial interest, we will be interested in estimating the degree to which an effective dissemination plan can be carried out in these schools in order to evaluate the results.

3. Network Infrastructure Requirements

3.1 Networking Requirements

In the following paragraphs, further information is provided for (a) the basic network architecture of the Greek Schools Network, (b) the IPv6 addressing schema deployed, based on the RFC3849, and (c) the configuration mechanism for the end users (in our case schools).

3.1.1 GSN architecture

The logical architecture of the GSN, operated by CTI, is shown in the next figure.

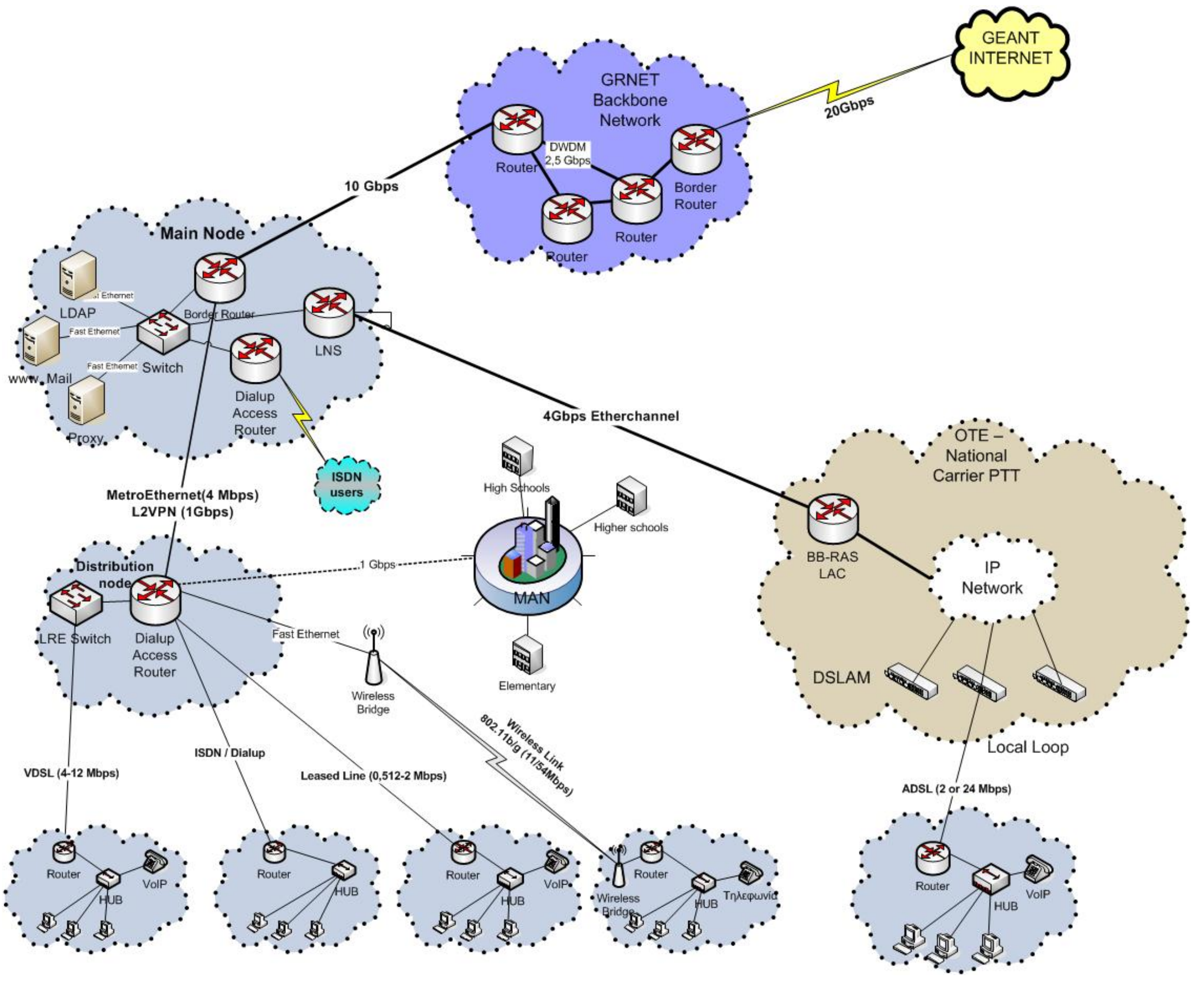

Figure 3-1: GSN Architecture

The figure depicts the six different technologies that are used in order to interconnect schools into the GSN and, thus, to the Internet. More specifically, every school located in Greece, is connected to the Internet using one of the following technologies:

- ADSL links with access bandwidth at 2-24 Mbps.

- Ethernet with access bandwidth at 1 Gbps, through Metropolitan Area Networks of the public sector, available to numerous municipalities across Greece.
- Wireless link with access bandwidth at 11-54 Mbps.
- Leased Lines with access bandwidth at 0,5-2 Mbps.
- VDSL with access bandwidth at 4-12 Mbps.
- ISDN/Dialup access with access bandwidth at 64-128 Kbps.

The majority of schools in Greece, approximately 95% of them, are connected to GSN using ADSL technology. Nowadays, there is also a significant growth in the number of schools connected to GSN by using Ethernet technologies, mostly because GSN is currently pursuing to utilize as much as possible the optical Metropolitan Area Networks that have been deployed by several municipalities across Greece in the previous years.

Aggregation of traffic is done either to a prefectural node, called distribution node, or to the central LNS[4] farm using the national carrier IP infrastructure. The prefectural node forwards the traffic to the main node where also most of the core services of the network are hosted. Finally, GSN has a single 10 Gbps connection to the Internet through GRNET backbone network.

3.1.2 IPv6 Addressing schema

Since 2003, GSN has been delegated a /47 and one /48 IPv6 address spaces from GRNET, the LIR for the research networking infrastructures in the country. The current address space is not adequate to fulfill the future needs of the school networks and, thus, it will be fully revised in the near future.

The current IPv6 addressing schema has been provided by the GSN's NOC, as follows:

- 2001:db8::1300 (/47) assigned to access network
- 2001:db8::1302 (/48) assigned to backbone network

The first IPv6 segment has been split in two equal parts (/48) and the following assignment has been made:

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[4] *L2TP Network Server*

IPv6 Block 2001:db8:1300::/47	Assigned Network	Start IP (prefix /128)	End IP (prefix /128)	/64 Subnets
Kindergartens	2001:db8::1300::/51	2001:db8::1300:0000::	2001:db8::1300:1FFF: FFFF:FFFF:FFFF:FFFF	8.192
Primary Schools	2001:db8::1300:2000::/51	2001:db8::1300:0000::	2001:db8::1300:3FFF: :FFFF:FFFF:FFFF:FFFF	8.192
Secondary Schools	2001:db8::1300:4000::/51	2001:db8::1300:4000::	2001:db8::1300:5FFF: :FFFF:FFFF:FFFF:FFFF	8.192
High Schools	2001:db8::1300:6000::/51	2001:db8::1300:6000::	2001:db8::1300:7FFF: :FFFF:FFFF:FFFF:FFFF	8.192
Technical Schools	2001:db8::1300:8000::/51	2001:db8::1300:8000::	2001:db8::1300:9FFF: :FFFF:FFFF:FFFF:FFFF	8.192
Directorates	2001:db8::1300:A000::/51	2001:db8::1300:8000::	2001:db8::1300:BFFF: :FFFF:FFFF:FFFF:FFFF	8.192
Various entities	2001:db8::1300:C000::/51	2001:db8:1300:C000::	2001:db8::1300:DFFF ::FFFF:FFFF:FFFF:FFFF	8.192
Unassigned	2001:db8:1300:E000::/51	2001:db8:1300:E000::	2001:db8:1300:FFFF: :FFFF:FFFF:FFFF:FFFF	8.192
Unassigned	2001: db8:1301:::/48	2001:db8:1301::	2001:db8:1301:FFFF: :FFFF:FFFF:FFFF:FFFF	65.536

Table 3-1: Addressing Plan

According to the previous table, different address blocks are allocated to different school categories, e.g. primary schools, secondary schools, etc. Every school connected to the GSN is provided a /64 subnet to be used for its own internal LAN. By the time the address space was allocated to each school, this address space was considered adequate for future expansion. However, for management purposes, e.g. the support of multiple LANs per site, this address space has to be extended in the future. Note that address block 2001:db8:1301::/48 remains unassigned for future use.

3.1.3 IPv6 Implementation in GSN

In the following paragraphs the current state of the IPv6 implementation in GSN will be analysed pointing out some of the current issues regarding the mass deployment of IPv6 for the services that GSN is offering to its users.

The backbone network of GSN is fully IPv6 enabled including IPv6 support on all the point to point (p2p) links of the primary and secondary nodes of GSN, as described in section 3.1.2. In addition, the peering with GSN upstream provider (GRNET) is also IPv6 enabled (dual-stack). OSPFv3 has been also selected as a routing protocol for IPv6 interconnection within the GSN.

Therefore, the backbone network of GSN is dual stack i.e. supports both IPv4 and IPv6.

On the access network, IPv6 interconnection has been activated for the ADSL users, i.e. the 95% of the schools. This has been achieved by enabling IPv6 on the LNS and on the radius profiles of each ADSL router connected to GSN. The process is described in more detail in **¡Error! No se encuentra el origen de la referencia.**.

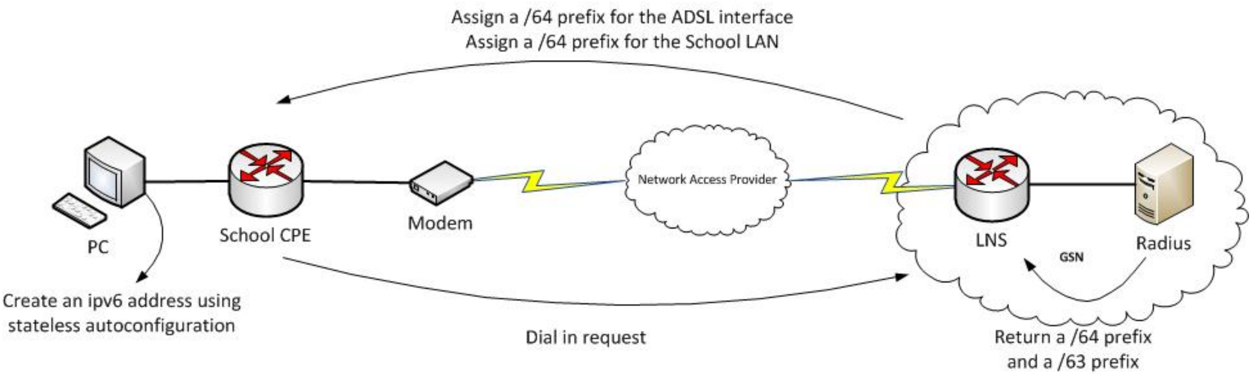

Figure 3-2: IPv6 assignment to a broadband (ADSL)-connected school

GSN offers a variety of services to its users. Those services include basic services, such as DNS services, electronic mail, FTP services, etc. In addition, more advanced services, such as web hosting, synchronous/asynchronous learning, collaborative tools etc. are provided for specific user groups. The majority of the aforementioned services are hosted in the central GSN data centre.

The majority of GSN services support IPv6. However, a recent software problem (bug) in the SSL termination in the GSN load balancers forced NOC to temporarily disable IPv6 access for the services running behind those load balancers. By the time the bug is fixed, expected within 2012, IPv6 access to services will be fully restored.

3.2 Security Requirements

GSN applies security filters, either by using hardware firewalls or by enabling access control lists on multiple levels of its network infrastructure. More specifically, the rules are applied, but are not limited to, on the following:

- Traffic incoming to GSN (schools) LANs from the Internet.
- Traffic outgoing from GSN (school) LANs.
- Traffic incoming to GSN servers from the Internet.
- Traffic outgoing from GSN servers.
- Traffic inside GSN between (school) LANs and servers.

GSN has been running as a network infrastructure for over a decade using IPv4 and, thus, has established strict security rules for the aforementioned traffic. Those rules have been expanded to also cover IPv6 traffic after it has been enabled in GSN.

As far as users are concerned, GSN does not limit their traffic to the Internet. In particular, GSN:

- Subjects users' web traffic to pass through GSN's proxy servers, by using policy routing,
- Prohibits all traffic originated by the users and has as destination GSN's administrative subnets.

The aforementioned measures have been taken, mainly, in order to prohibit/avoid specific content, e.g. content related to gambling, drugs, porn, hate talk, etc., to be delivered to pupils and also to avoid network attacks initiated within the GSN. Similar restrictions have been applied to IPv6 traffic. These restrictions are implemented using semi-automatic access control lists on the virtual template of the ADSL users and are applied to each user during the establishment of the connection to the ADSL infrastructure of GSN.

3.3 Data Privacy Requirements

There is a number of security issues associated with smart meters, which is planned to be deployed in the context of GEN6. As far as the data privacy section is concerned, these issues include the non-repudiation of transactions and the privacy of the power consumption data. A key aspect for the Greek IPv6 pilot integration in a secure and safe way is to perform a detailed security threats analysis among devices, protocols and applications involved.

To ensure privacy of data transferred between the IPv6-enabled smart energy meter in schools and the remote cloud-based servers, has been planned to enable SSL encryption. The cloud servers will be responsible for collecting and aggregating data from the school meters, and they will be the unique communication point with third parties outside the GSN. Thus, the exposure of energy information to third parties will be done only after authorization of cloud based remote unit.

3.4 Monitoring & SLA Requirements

The IPv6-enabled advanced metering infrastructure (AMI) and services will be monitored during the GEN6 demonstration phase in order to quickly identify problems related to the provided services to the end users. In addition, the GSN processes and the monitoring applications applied by the corresponding NOC will be extended in order to ensure that the GEN6 advanced metering infrastructure is efficiently monitored on a 24-hour basis.

In the context of GEN6, the following parameters will be regularly monitored:

- Connectivity status over IPv6 as well as IPv4 for all the smart meters installed using ICMPv6/v4.

- Connectivity status over IPv6 as well as IPv4 of the Intelen cloud infrastructure using ICMPv6/v4 and HTTP.
- The bandwidth utilisation to/from the Intelen cloud infrastructure used for the collecting aggregated traffic from the smart meters.
- The application level delay (HTTP) and packet loss to the Intelen cloud infrastructure application server.
- The average CPU utilisation of the physical machines used in the Intelen cloud infrastructure.

As referenced previously, the monitoring of the advanced metering infrastructure (AMI) will be integrated into the monitoring processes that GSN has established in order to manage the national networking and service infrastructure. In addition, the Intelen technical department will publish to the GSN NOC of CTI a view of the physical infrastructure used in the GEN6 pilot.

The GSN and Intelen will cooperate in order to ensure that the IPv6-enabled AMI and the cloud services will be available for 99,9% of the time. This means that on average a smart meter will not be remotely accessible for less than 9 hours per year. This period of time does not include any network connectivity failures in the GSN backbone as well as maintenance-window periods. In addition, the Intelen cloud infrastructure will be operational for end-users for the corresponding period of time.

4. System & Data Management Requirements

As mentioned previously, the scope of the Greek IPv6 pilot in Schools is to achieve the reduction of energy consumption in fifty schools by exploiting energy awareness services based on smart meters. Smart metering generally involves the installation of an intelligent meter, the regular reading and processing of energy-consumption data, and the provision of feedback on consumption data to the customer.

A "smart" meter has the following capabilities:

- Real-time or near real-time registration of electricity use.
- Local and remote access to the meter (on demand).
- Remote limitation of the throughput through the meter (in the extreme case cutting of the electricity to the customer).
- Interconnection to premise-based networks and devices (e.g. distributed generation), ability to read other, on-premise or nearby, commodity meters (e.g., gas, water).

The 'intelligence' of the meter is incorporated in the electricity meter. It has three basic functions:

- Measuring the electricity used (or generated).
- Remotely switching the customer offer.
- Remotely controlling the maximum electricity consumption.

The electricity meter communicates by means of a modem. An important characteristic is the communication infrastructure used by the smart meter for this communication. Amongst the possibilities that exist are: Power Line Communications (PLC, using the existing electricity grid), a wireless modem (GSM Distributed Generation of GPRS) or an existing permanent Internet connection (ADSL). Smart metering is often referred to as *automated meter reading* (AMR), or in the case of real-time two-way communications, as *advanced metering infrastructure* (AMI).

The smart metering infrastructure in each building at the Greek IPv6 pilot consists of a consumption-metering device (abbreviated CMD) along with its CT's (current transformer), a transmitter and the i-box. The i-box is a smart device that acts as a data bridge between the meter and the Internet and is capable for a series of services, including the following:

- It performs basic calculations in order to translate the raw data that are collected by the specific CMD to information that can be handled by Intelen centralised (cloud) infrastructure.
- It acts as memory storage (buffer) so that in case of a network or other error, data are

not lost, but are stored for transmission as soon as network connectivity is re-established.

- It extracts the appropriate key performance indicators (KPIs) from the raw data received by the CMD.
- It receives instructions for extra KPIs from Intelen Meter Data Management (MDM) System.
- It performs error handling concerning the CMD, the connectivity of the system and the i-box itself.

The Intelen smart metering system currently supports the IPv4 protocol. In the context of GEN6, the smart metering system will be upgraded to support IPv6 functionality, i.e. to transport the collected energy information over IPv6. The collected data will be stored, aggregated if necessary, and analysed in Intelen's Cloud, which also has to be upgraded to support IPv6 requests. Services providing energy KPIs, such as the kWh consumed and the CO_2 emitted, will be offered according to Software as a Service (SaaS) model, by exposing Web Services, to authorized GEN6 partners for visualization purposes. All partners could consume these services by using Intelen's IPv4 or IPv6 cloud's global address. Data will be available through Intelen's APIs in JSON, XML, plain text, HTML and CSV format. The most appropriate format is JSON due to its flexibility and the smaller size of its files. The available API methods will include: daily data in one-hour intervals; monthly data in one-day intervals; yearly data in one-month intervals.

For data security reasons and due to the javascript cross domain restrictions, a frontend parser is required in order to receive data from API and forward them to the application.

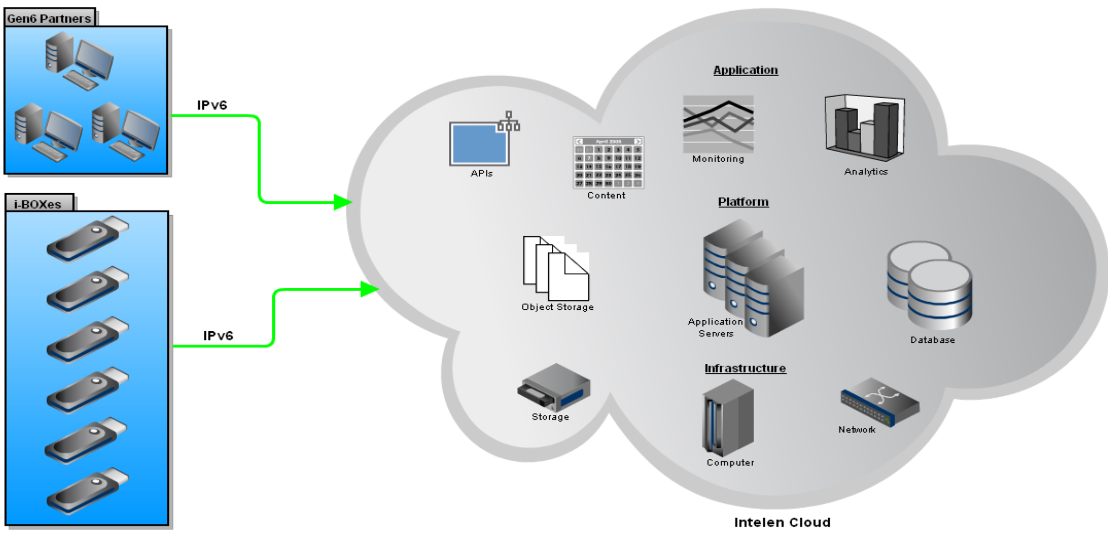

Figure 4-1: Intelen Cloud Infrastructure

4.1 Smart Meters Connectivity Requirements

The connectivity requirements for the smart meters are described next. The most well-known protocols for transferring data from smart meters are Serial, Modbus, Ethernet and DLMS / IEC 62056. In Intelen's smart metering system, it is used a data cable (with a serial-to-USB adaptor) that will send data to the i-box. Meters will expose their measurements in serialized XML format. As mentioned before, when i-box loses connection to the Internet, it collects the data and stores them in its memory in order to send them to MDM system as soon as the Internet connection is restored. The i-box can store these data to its memory for more than 20 days and, as a result, Internet loss can be handled without losing them.

For security reasons network administrators will have to block any (incoming / outgoing) traffic to the i-box except for the HTTP requests from the i-box through ports 80 (HTTP), 22 (SSH), 443 (HTTPS) and 37 (NTP). The port 37 (NTP) is needed for synchronization of the smart meters. Outgoing connections through ports 80 (HTTP), 22 (SSH) and 443 (HTTPS) should be permitted only to specific address space corresponding to Intelen's cloud infrastructure. Outgoing connections through port 37 (NTP) should be permitted to any server. Incoming connections to port 22 (SSH) should be permitted only address space corresponding to Intelen's cloud infrastructure.

The information transmitted per i-box is estimated to approximately 1.5kB every 15-minute period.

4.2 Cloud-based Data Aggregation Requirements

To report power quality it is necessary to reduce the data that is sampled at high sampling rates down to a form that is both concise and useful, without the loss of important detail. The method of reducing high-speed data down to more useful data is known as aggregation, and the time period over which the data is aggregated is called the data aggregation interval. It is important to note the distinction between data aggregation interval and data sampling frequency. The sampling frequency is a basic function of the monitoring instrument and the associated digital signal processing. The data aggregation interval is the time period over which the sampled data is combined to produce an average. Common aggregation intervals include 3 seconds, 10 seconds, 10 minutes, 15 minutes, 1 hour and 2 hours; though in reality any aggregation interval is possible. The data aggregation interval is very important because (depending also on the type of signal to be measured) a very long aggregation interval may result in the loss of important detail due to the RMS averaging processes, while a very short interval may result in copious amounts of data that are difficult to assess, may not be meaningful and present a difficult storage problem if the data is to be retained. Therefore the aggregation interval must be chosen so that the amount of data to be analysed is reduced to a manageable form whilst ensuring that sufficient detail is still available to ensure that a good indication of disturbance level is achieved. The recommended data aggregation interval is 15 minutes according to the standards for energy consumption measurement. The i-boxes will measure the energy consumption with a sampling period of ~6 seconds. Data from the i-boxes will be aggregated and sent to the storage cloud every 15 minutes. On Intelen's Cloud, further aggregation/analysis will take place in 24 hours intervals for infrastructure fault detection, application performance, and storage and speed optimization.

4.3 Cloud-based Analysis Requirements

Intelen Cloud Computing Infrastructure exhibits all key characteristics, like Virtualization, Reliability, Scalability, Performance, Security, Maintenance, out-of-the-box. Intelen Cloud exposes APIs well documented and unique to their implementation. Furthermore, Intelen Cloud node balancer is accessible to service consumers using both IPv4 and IPv6. Therefore, no additional requirements need to be defined for the i-boxes and the Gen6 Partners to access Intelen services.

5. Conclusions

The previous sections provided an analysis of IPv6 services in GSN and the GEN6 plans for the installation of intelligent energy meters in schools threat three adjacent prefectures in Greece. Initially, administrative and school requirements for the final selection of the participating schools are presented. Network level requirements as well as network limitations, such as security, SLAs, data management, etc., towards the installation of the power meters are identified. In addition, smart metering infrastructure and cloud based aggregation system have been described highlighting the connectivity issues and cloud-based requirements.

The Greek IPv6 pilot aims to reduce the schools' carbon footprint by at least 10% and to offer advanced real-time energy efficiency services over IPv6-enabled grids. It focuses on positively affecting the students' behaviour and raising energy awareness in the school communities. This project will demonstrate to participating students in real time the energy consumption and environmental implications of their actions, providing significant motivation for behavioural changes. Given the long lifespan of most governmental buildings (including schools), the relative energy efficiency of school buildings will influence energy consumption for many years in the future.

The Greek IPv6 pilot, upon successful implementation and dissemination of the results, may constitute a point of reference for wide scale deployment of IPv6 services in the Greek public sector infrastructures, either for networking or cloud computing ones. There is also a probability of high influence in private sector infrastructures. The pilot targets in reducing energy consumption based on the provision of advanced services, for which the IPv6 is an enabling technology. Finally, the dissemination plans that will be carried out within the schools as well as in the wider community will motivate the establishment of a strong collaboration framework between the ICT sector, the smart building & automation vendors and public authorities.

6. REFERENCES

1	Cookbook on deploying IPv6 in School Network - http://www.6journal.org/archive/00000236/
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