SP ENERGY NETWORKS

Flexible Networks for a Low Carbon Future

Monitoring Data Management

iHost System Report

July 2015

1. Project Background

From 2012 - 2015, Nortech was a collaborative partner in SP Energy Networks' (SPEN) LCN Fund project: Flexible Networks for a Low Carbon Future (Flex Net).

Nortech Management Limited was identified as a project partner because it is a specialist company in monitoring, control and integration of complex systems for electricity networks. Nortech designs and supplies remote site monitoring solutions and other specialist technology to electricity utilities, telecom network providers, the security industry and other blue chip companies with geographically spread networks and assets.

Nortech's core business involves the supply and monitoring of fault passage indicator solutions, as well as the design, development and supply of remote telemetry solutions. Data is gathered and communicated to Nortech's iHost system – a software platform, utilised to varying degrees by each of the UK DNOs, for data concentration, protocol conversion, field device management, data storage and data visualisation.

Prior to the commencement of the project, Nortech worked with SPEN on a number of previous project and deployments. One such project was the LCN Fund Tier-1 project "Implementation of Real-time Thermal Ratings", which was a forerunning trial of the 33kV dynamic thermal ratings deployment as part of Flex Net. In addition, SPEN had previously adopted Nortech's iHost platform for the middle-management of data and devices downstream of the Network Management System (NMS).

On this basis, Nortech was selected by SPEN to be responsible for collecting the data from the remote field devices, deployed as part of Flex Net. Nortech's remit was also to store the data and take responsibility for disseminating it to the other relevant parties within the project.

Along with SPEN, Nortech collaborated with TNEI and the University of Strathclyde, as the other project partners. Nortech also worked closely with the manufacturers of monitoring equipment to integrate their devices into iHost.

Nortech provided a £60,000 in-kind contribution, in the form of developments and enhancements to iHost, to add benefit and transferrable outcomes to the Flex Net project for UK DNOs and as a result, their distribution customers.

2. Scope and Objectives

Working with other project stakeholders Nortech was responsible for designing the data transport, visualisation and reporting system for the project. In summary the scope included:

- Requirements gathering from all stakeholders especially the data consumers;
- Design of overall system to ensure performance, data storage, data retrieval, back-up and security requirements were met;
- Modification of the existing iHost system to provide visualisation and reporting as required and specified by the users;
- Integration work with the substation monitoring devices to accept data into iHost;
- Integration work with 3rd party systems (for example, where iHost was an intermediary to convert proprietary data formats into standard data formats);
- Supply of SIM cards; and
- Supply, install and maintain the central server's hardware and software.

In order to achieve the above and in addition, Nortech provided both technical consultancy and system integration work.

Nortech's objectives were defined by a number of milestones, as outlined below:

1. Definition of user requirements;
2. Completion of substation monitoring device interfaces to iHost;
3. Initiation of monitoring service with provision of SIM cards and installation of iHost servers;
4. Completion of design document, user scheme modifications and user interface changes ready for testing;
5. On-going consultancy services;
6. On-going monitoring service in the form of SIM card provision and data hosting via iHost.

3. Success Criteria

The success criteria linked directly to the timely delivery of the above-mentioned milestone deliverables to the satisfaction of SPEN and other stakeholders. Targets were set, such as the deployment of the monitoring infrastructure ahead of equipment installations to ensure that data could be collected from Day One of commissioning.

Furthermore, Nortech also aimed to support SPEN with their over-arching Successful Delivery Reward Criteria objectives, defined as part of the original Flex Net bid (for example, deploying innovative solutions in England, Scotland and Wales).

Nortech's success criteria also centred around the delivery of quality customer service and technical support. The project's success was also measured by the opportunities to secure of follow-on work with SPEN and the experience gained through the integration of new substation monitors within iHost, leading to opportunities for downstream work with other UK DNOs.

4. Details of Work Carried Out

4.1. Gather customer requirements

The first stage of the project for Nortech was to work with SPEN and the other project partners to gather the requirements for the projects. Meetings were held with the project stakeholders to discuss how they would like the data collected, and in what form they would like the data delivered (frequency, format, delivery mechanism etc.) from these meetings an internal requirements specification was produced, this in turn allowed Nortech to design a system that would meet the requirements of each of the project partners.

4.2. System Architecture

Due to the time constraints imposed by the project, the options of SPEN adapting an in-house system, or procuring an in-house system were considered unlikely to deliver within the required project timescales. Nortech's iHost could be deployed to sit outside of SPEN' corporate systems, thus de-risking main business operations. The system architecture was relative quick to deploy as it was not subject to the normal time constraints as an internally sourced solution.

Once the requirements had been captured from the project stakeholders, a high level system architecture was designed, as given in Figure 1. This covered how the various system components would communicate together.

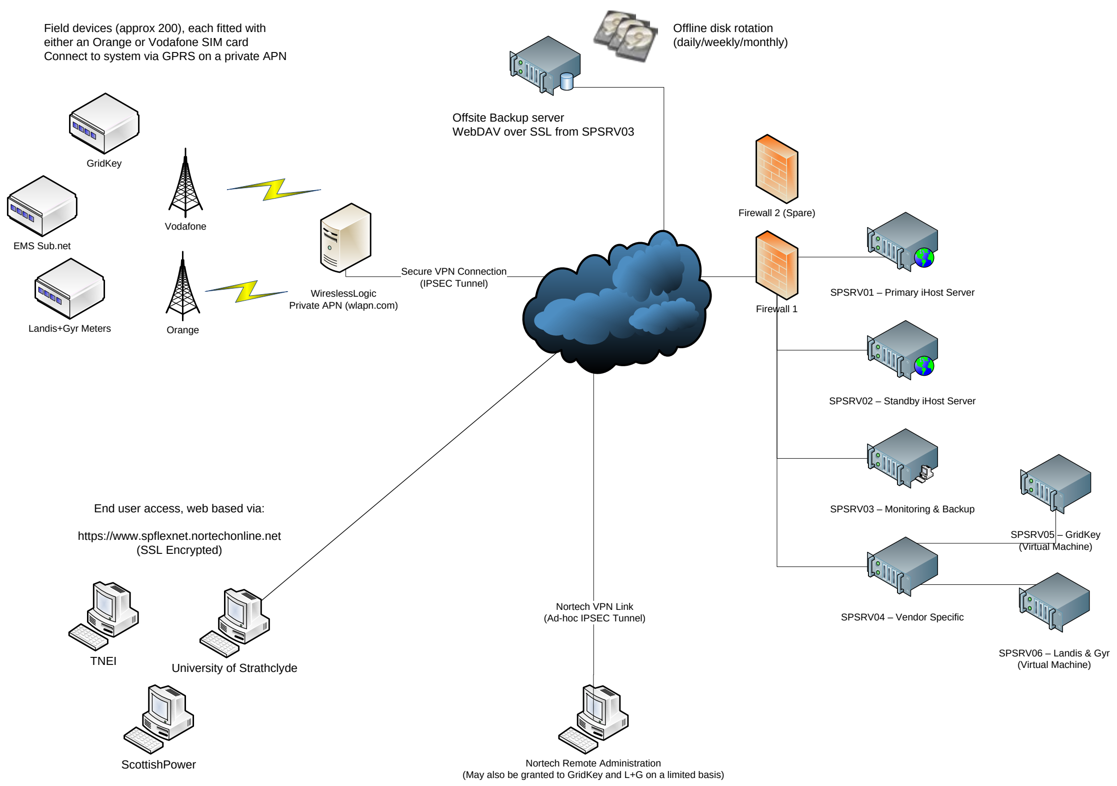

Figure 1 - System Architecture

The overall system consists of various components, hosted together in a single co-location rack in Nortech's datacentre.

4.2.1. Firewall

Security was an important consideration for the project, a WatchGuard XTM330 firewall was selected to ensure that only very specific services were accessible from the public Internet, whilst allowing Nortech remote access to the servers for support and administration.

Once commissioned the firewalls were maintained through the project, updating rules where necessary and performing firmware upgrades at specified intervals. A second cold-standby firewall was supplied and configured as part of the project, so that in the case of a firewall failure there would only be a minimum interruption to service whilst the cold standby firewall was powered up.

4.2.2. Private APN Link

In order to protect the remote field devices from being internet connected, their GPRS traffic is sent to a Private APN. This provides a gateway from the devices that keeps their communications separate from internet traffic.

In order to get the communications from the Private APN to the iHost servers a link into the Private APN was required. This was achieved by means of a Virtual Private Network (VPN) to the supplier of the SIM cards. The VPN traffic was encrypted using IPSEC, and terminated at the Firewall.

4.2.3. iHost server

The iHost server was the main component of the system. This is responsible for:

- Communicating with the field devices, using the variety of different protocols
- Storing the data in an online database
- Holding meta data about the various sites
- Exporting the data in various formats, as requested by project partners.
- Making the data available via WebDAV for project partners to download
- Making the data available via a user friendly web interface

iHost is hosted on two servers, one acts as a primary sever, carrying out the device communications and hosting the web interface. The second server holds a replica of the database from the primary server. Should the primary server fail, the secondary server can be quickly promoted to the role of primary server, allowing the service to be resumed with a minimal interruption. (All of the field devices are able to buffer data for a limited period of time in the case of a server outage)

The servers themselves have redundant power supplies, fans and hard disks, these greatly reduce the chance of a server failure. They are also fitted with Remote Administration Cards (RAC) these give remote KVM (Keyboard, Video and Mouse) access allowing the servers to be administered remotely. This was an important feature as the servers were co-located at a datacentre remote from Nortech's normal offices, travelling to the data centre to perform administration would have greatly increased the time it would have taken Nortech to respond to technical support requests. The RAC also allows servers to be powered up and down remotely, and reset, if required.

4.2.4. Monitoring and Backup Server

A separate server was commissioned to store backups, and provide continuous monitoring of the system. Backups from the various servers are collated onto this server, before being copied offsite.

The backup server has a basic level specification, with 2TB of disk space for storing the data backups.

4.2.5. Offsite Backups

Whilst 3 copies of the data are stored in the data centre (iHost primary server, iHost secondary server and backup server) a separate offsite copy is also made on a regular basis, this guards against total destruction of the data centre, and also malicious attackers gaining unauthorised access and deliberately destroying the data. The Offsite backups are stored on media that is taken offline for additional security.

4.2.6. GridKey Server

Whilst the iHost server handles the data collection from the GridKey field devices, it does not implement the functionality required to remotely configure and manage firmware for the units. To provide this functionality the Gridkey software was installed on a separate server. As the workload of this server is very light, it was commissioned as a virtual server, sharing the same physical server as the Landis+Gyr software. Making this system two virtual hosts allowed Nortech to grant Gridkey and Landis+Gyr remote access to the servers, independently so they could provide remote technical support to the project and their devices.

4.2.7. Landis+Gyr Server

A small number of Landis+Gyr Smart Meters were installed as part of the project. These communicate using the DLMS protocol. The DLMS protocol wasn't implemented as a supported iHost protocol at the time of the project. Given the small number of devices to be installed by the project, it was considered too costly and time consuming to add DLMS protocol to iHost. An alternative approach was adopted, this involved installing the Landis+Gyr 'Advance' software to communicate with the meters. This communicates with the Smart Meters using DLMS protocol, and stores the data in an internal data store. Data is then exported from Advance in CSV format on a daily basis. The CSV files are then imported by the iHost server, and the data made available in the same manner as the other devices monitored by the project.

4.3. System Sizing

A study was also undertaken to understand the number of devices that would be deployed throughout the lifetime of the project, and an estimate of the volume of data that these devices would generate.

In summary:

- 200 sites, on average with 150 data points each
- 30,000 data points in total
- 144 readings/day/point
- 4,320,000 readings/day
- 1,576,800,000 readings/year x 2 years = 3,153,600,000 total readings (estimated)

This allowed Nortech to decide on a hardware specification for the project servers, and ensure that sufficient power, cooling, and Internet Bandwidth would be available to meet the needs of the devices and the end users.

4.4. Supply SIM cards

Once the basic data communication requirements had been defined for the various devices being deployed by the project, then negotiations were entered into with SIM card providers to select suitable SIM cards for this project.

WirelessLogic were selected to provide the SIM cards, using Vodafone and Orange as the network operators. WirelessLogic add a private APN service to the SIM cards provided by the network operators. This private APN allows the communications to operate as a closed system, rather than passing the data over the public internet.

The private APN also allows static IP address to be assigned to the SIM cards. Whilst this is technically possible without the use of a private APN, the supply of IPv4 addresses has been exhausted, and SIM cards with Public Fixed IP addresses are no longer available from suppliers. Static IP addresses are required for devices that communicate with DNP3.0 and DLMS protocols, as the connections are established by the central host (rather than the device)

Following signal level surveys by SPEN, it was decided that Vodafone SIM cards would be utilised for the Wrexham and Whitchurch area sites, and Orange for the St. Andrews sites.

SIM cards were shipped directly to equipment suppliers so they could be factory installed and tested prior to dispatch. Minimising the risk to the project when commissioning equipment on site.

4.5. Purchase and commission server hosting space

As part of the System Architecture design, the space, and power requirements for the servers and communications equipment were determined, this allowed Nortech to select a supplier for providing the co-location server hosting facilities.

Pulsant were selected as the preferred supplier, being able to offer space at a competitive price, and having a track record of working with Nortech on previous projects, where they have provided a high quality service and facilities throughout the UK.

The data centre facility provides empty half height (22U) 19" server rack, with 8A of power, and a high speed internet connection. This was deemed sufficient server space for the initial requirements of the project, whilst providing some headroom should additional space or power have been required.

Facilities provided by the data centre include redundant Uninterruptable Power Supplies (UPS), Generators, Cooling, and Internet Connectivity, these work together with the equipment installed by Nortech to ensure that the system benefited from a very high degree of availability throughout the project.

The data centre is also responsible for the physical security of the servers, access to the data centre is controlled by the use of strict identity checks, CCTV and access cards. Once inside the data centre, access to the cabinet where the servers are located is controlled by the use of a combination lock.

The servers installed in the datacentre are depicted in Figure 2.

4.6. Purchase and commission servers

Nortech used the figures obtained from estimating the volume of data to be collected, along with the experience from other similar projects to produce a specification for the servers, then worked with suppliers to procure hardware to this specification.

Once the hardware was purchased, iHost was installed, configured at Nortech's office, and the completed servers installed at the data centre alongside the required networking equipment.

Installing the servers included a continuous monitoring system (Nagios) that checks 60 health parameters every 5 minutes and notifies Nortech support staff by email or SMS message in the event of any problems being detected. Free disk space is an example of a monitored parameter, should the free space drop below 25% on any of the server disks, an alert is sent, preventative action can then be taken to ensure that a lack of disk space doesn't cause any interruption to service.

For servers with redundant hardware, it is very important to monitor to health of the hardware components, for example, should a power supply fail the server will continue to function, however it is important that the failed power supply should be replaced as quickly as possible to eliminate the chance of a second power supply failure resulting in a loss of service.

The Nagios monitoring system is depicted in Figure 3.

4.7. Setup links to SIM providers

Once the firewalls were in place, the VPN link to the SIM card provider was established and tested. Firewall rules were also established to ensure that the SIM cards only provide access to the bear minimum of services required to allow devices to report data.

Figure 2 - Servers installed in the data centre

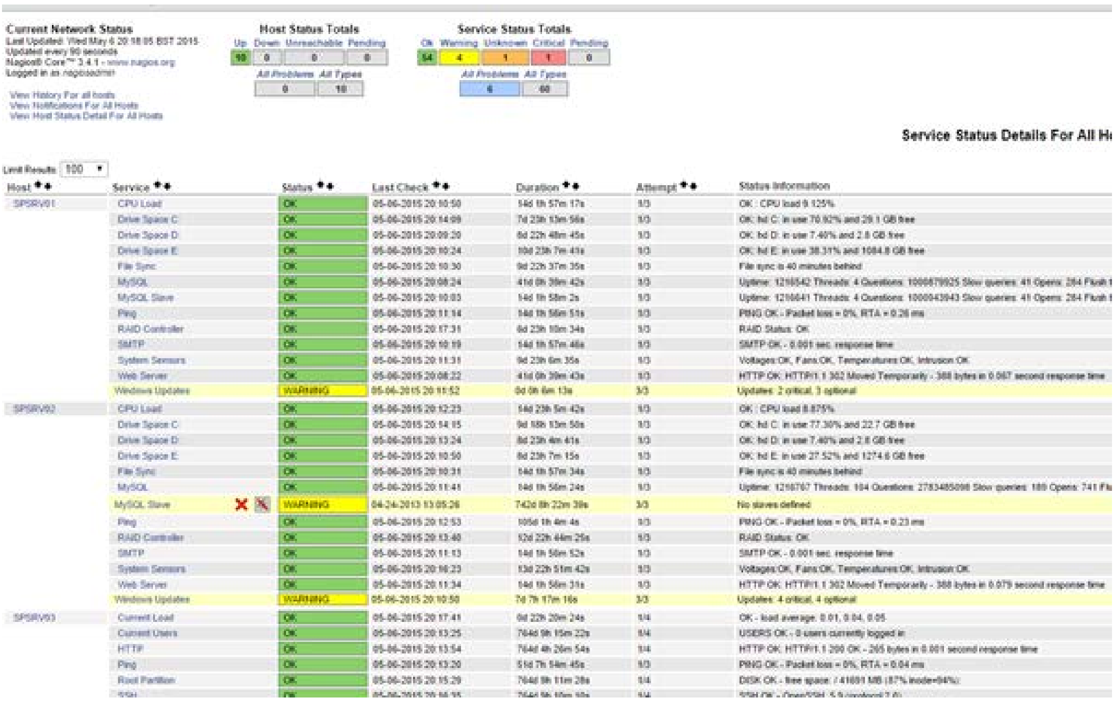

Figure 3 - Nagios server monitoring system

4.8. Modify iHost software for updated Gridkey protocol

Gridkey made some changes to the protocol that their equipment uses to report data to the central host, in order to accommodate a requirement from the Flex Net project that instantaneous values were recorded, rather than averages.

Once this change had been tested in Nortech's test environment, it was deployed to the Flex Net iHost server, prior to any Gridkey devices being deployed.

4.9. Provide technical support

Throughout the lifetime of the project, and in particular during the installation and commissioning of the field devices, Nortech provided telephone and email support to SPEN and project partner staff, as and when required.

An example of an issue that Nortech were able to provide for is providing assistance with resolving communications stability problems experienced by the sub.net devices.

4.10. Export data from iHost

4.10.1. University Research Partners

Nortech developed data export routines to export the data in a CSV file format, agreed with the University of Strathclyde and TNEI, this data was automatically exported on a daily basis, and made available to authorised users to download using the WebDAV protocol.

4.10.2. Distributed Grid Analytics (DGA)

IBM were contracted by SPEN to look at new ways of analysing the data captured by the Flex Net Project. This involved Nortech adding various new metadata fields to various sites within the iHost database, then exporting the data in a particular format as agreed with IBM. The additional metadata allowed the DGA to cross reference assets on the electrical model of the network to the values being taken. This data was made available via FTPS for IBM to download from the iHost servers directly.

4.11. Integrate data availability reports into iHost

One of the first tasks the University of Strathclyde undertook with the data was analyse it for completeness. As part of this process they developed a series of Excel macros that allowed missing data to be easily visualised on a coloured 'heat map'.

Nortech undertook to integrate these reports into iHost, so that they could be quickly and easily run to allow users to check that all of the data was being reported correctly.

The data availability visualisation in Figure 4 highlights devices that are having problems with communications, but also system wide issues that may have affected all of the devices communicating with the system.

4.12. Provide Mimics for Substation monitors

Mimic displays were developed to allow the real time data being collected from substations to be quickly and easily visualised. The mimic displays were developed based on requirements specified by multiple DNOs (for example Electricity North West, as well as SPEN), facilitating replication of the solution beyond the project demonstration. An example mimic for an LV substation is given in Figure 5.

4.13. Collecting data from Smart Meters

A small number of Landis+Gyr smart meters were deployed by the FlexNet project to collect voltage data from the end of feeders at customer's supply points.

As these meters don't support any of the many protocols supported by the iHost servers, the data is initially collected by Landis+Gyr 'Advance' software, running on a server, hosted in the same rack as the iHost servers. This software collects the data, then exports it in CSV format, where it is then passed to the iHost servers. The iHost servers import this CSV data and make it available alongside the data from the other monitoring equipment.

Figure 4 - Data availability visualisation

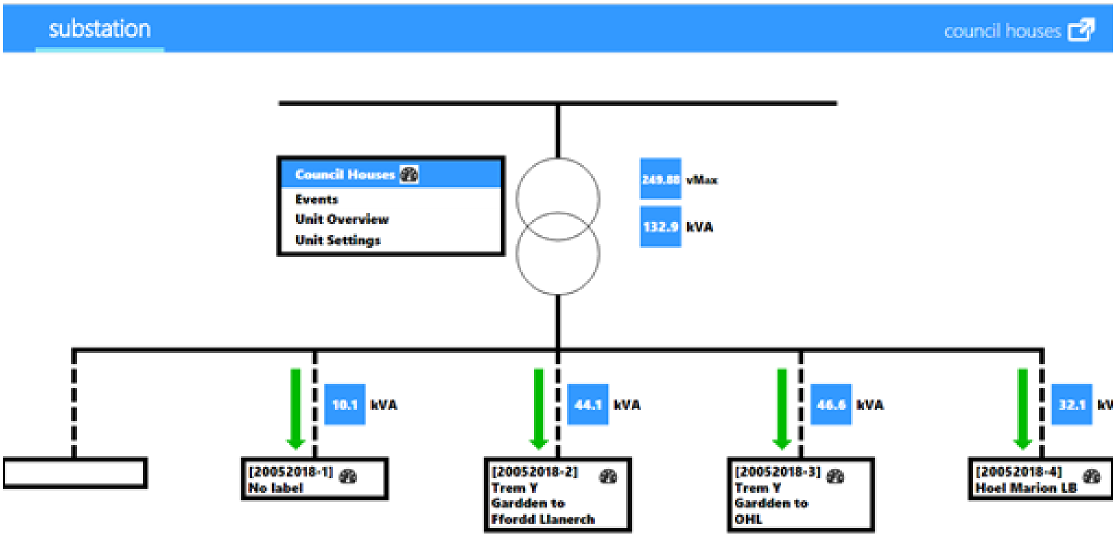

Figure 5 - LV Substation overview mimic

5. The Outcomes of the Project

The following outcomes were achieved in this project:

- Implementation of a communications infrastructure, consisting primarily of an estate of SIM cards and associated VPN links to SIM card operators. This infrastructure was to be ready for service within several weeks of the start of the project, in order that data should be collected for early as possible for later analysis. GSM based communications were chosen as they provide good coverage over the project area, and can be deployed rapidly.
- Implementation of a data gathering platform. Nortech's iHost system was chosen to collect data from the remote field devices, procured by SPEN as part of this project. This had be maintained an operated throughout the project to ensure that data was collected from the devices in a timely manner, and that no data from field devices was lost. iHost was select as a single system that was able to support all of the types of monitoring equipment being deployed as part of the project. This meant that only one data collection system was required for the whole project, negating the complexity of deploying several systems. Modifying existing SPEN IT systems to accept data from the selected field devices would have been both costly and time consuming,
- Data hosting / dissemination. iHost acted the data historian for all of the substation data collected, and provided a platform for exporting it in the various formats required by parties in the project.
- Enhancements to iHost. Changes were required to iHost to improve the visualisation of the data, and support additional field devices. This included a mimic display to show data values for a substation in real time, and improvements to the iHost interactive trending features to allow the data to be easily visualised.
- Technical services and consultancy. Nortech provided technical assistance and consultancy throughout the duration of the project.

Field devices consisted of several types of equipment, installed in substations in the project two areas of Wrexham and St Andrews, the main types of equipment installed were:

- LV substation monitoring, GridKey MCUs installed at secondary substations to measure voltage, and outgoing feeder power flows. This is a self-contained unit that can monitor up to 5 LV ways. It includes an in built GPRS modem, and communicates using a proprietary protocol.
- HV substation monitoring, EMS Sub.net units installed at primary substations, to measure 11kV bus bar voltages, and outgoing feeder power flows. It communicates with iHost using the industry standard DNP3.0 protocol.
- Auto Recloser monitoring. Nortech Envoy units installed on several NOJA auto recloser points, to provide access to the voltage and power flow data collected by these devices. The Envoy uses DNP3.0 protocol to communicate with iHost.
- Weather Stations. At a select few Primary substations, weather stations were installed, to allow temperature, wind speed, wind direction and solar radiation to be measured and recorded as part of the dynamic thermal rating system
- Voltage Regulators. Nortech Envoys were used to collect data from two Cooper Voltage Regulators in North Wales and St Andrews. This data included voltages on either side of the regulator, power flows, and tap position.

- LV voltage supply monitors. A small number of Landis+Gyr smart meters were installed in end customer premises to allow the end of feeder voltages to be measured. These smart meters communicate using the standard metering protocol DLMS.

The total number of devices deployed by the project was as follows:

Device	Quantity
GridKey MCU	157
EMS Sub.net	65
NOJA Auto Recloser	28
Weather Station	6
Voltage Regulator	2
LV supply monitor	10

Nortech's monitoring solution has led to the cost-effective acquisition of 7 billion data readings a year. This is an order of magnitude greater than the typical DNO's current level of readings for primary substation feeder loads.

6. Performance Compared to Original Project Aims, Objectives and Success Criteria

Nortech succeeded in the timely delivery of each of its project aims and objectives, as listed below:

- Requirements gathering from all stakeholders especially the data consumers;
- Design of overall system to ensure performance, data storage, data retrieval, back-up and security requirements were met;
- Modification of the existing iHost system to provide visualisation and reporting as required and specified by the users;
- Integration work with the substation monitoring devices to accept data into iHost;
- Integration work with 3rd party systems (for example, where iHost was an intermediary to convert proprietary data formats into standard data formats);
- Supply of SIM cards; and
- Supply, install and maintain the central server's hardware and software.

In summary, the project's monitoring aspects were deemed a success by Nortech, SPEN and the other project partners.

SPEN highly values Nortech's quality of customer service, professionalism and 'problem solver' attitude. This has led to downstream opportunities for the exploitation of FlexNet's outputs and benefits.

7. Required Modifications to the Planned Approach During the Course of the Project

For Nortech the project proceeded broadly as originally planned.

Once the initial requirements had been gathered, it became apparent that iHost may struggle to process the quantity of the data being captured by the project. Improvements were made to the iHost data archive database and the process that moves data from the real time database to the archive database. Improvements to the archive database including improving the indexing on the data, this allows user queries to extract data from the database to be executed in a fraction of the time of the previous design.

8. Significant Variance in Expected Costs and Benefits

The costs for the communications and database (iHost) hosting services did increase proportionally in line with the project extended timescale, as the data would be required beyond the original planned date of the project cessation.

The benefits delivered by Nortech's iHost system and data capture, storage and availability did not vary significantly from the original plan. However, a number of additional benefits were realised during the course of the project:

- iHost is now able to monitor other types of devices, proving iHost as a concept for integrating multiple systems together for a "single point of truth";
- The technical support provided by Nortech to SPEN exceeded their expectations, not just in terms of the speed of response to technical issues but also because Nortech took ownership for system integration tasks and managed the constructive conversations with equipment suppliers on SPEN' behalf.

9. Lessons Learnt for Future Projects

The lessons learnt in delivering this project, from the monitoring, communications and data hosting perspectives, are summarised below:

- Engaging 3rd party suppliers to deliver externally hosted IT systems can be much quicker, and carry less risk than relying on the DNO internal IT departments to deliver new internally hosted solutions.
- 3rd party software cannot be relied upon to be defect free. Issues with the host software supplied by LV substation monitoring equipment suppliers and smart meter equipment suppliers have caused issues at times during the project.
- Poor cellular signal strength is not always easy to resolve, within a project area as large as the Flex Net project, there will always be areas where it is not possible to obtain a reliable cellular signal. For future projects, Nortech are recommending the use of Roaming SIM cards, these are able to select the network operator with the strongest signal at any particular location. The downside of roaming SIM cards is they are more expensive, particularly if large volumes of data are required.
- Off-site backups require high speed internet connections at both sites. Using the Nortech office broadband connection to send the backups offsite has proven to have insufficient bandwidth for a daily backup. Several cloud based backup services are now available, and these would probably make a more suitable final destination for the data.
- Better commissioning tests and checks when substation monitoring equipment is installed on site are required. Several problems were found late on in the project after equipment had been collecting data for over a year. This included voltages out by a factor of 10, and CTs incorrectly installed. Whilst it has been possible to correct a lot of the collected data, a more thorough commissioning process, utilizing iHost to validate data on the day of commissioning, would have removed further remedial actions.
- Currently exported data is available by pre-generated CSV files, however these are only accessible using a special WebDAV connection. Users without access to the WebDAV connection can download data on-demand from iHost using tool known as 'Analogue Readings by Time Intervals', which is rather tedious for downloading large quantities of data. A better approach would be to provide the CSV files for download from the iHost user interface.

Particularly if this allowed users to zip several weeks or months' worth of data together into a single file download.

- The tool used for carrying out the initial site radio surveys was rather complicated to use and required a high degree of radio network knowledge to correctly interpret the results. Since the project began, several simpler (and cheaper) tools have come to market, that make the task of selecting the best GSM network at a particular location much easier. Examples include the Dycon D2376.
- Experience from other projects that are collecting similar data has shown the large quantities of analogue data are more efficiently transferred to iHost using compressed CSV files, rather than DNP3.0 protocol. Further to this, this is normally easier for manufactures to implement, resulting in quicker deliveries and fewer software anomalies.
- The format of the CSV file export used to provide data to project partners doing data analysis, would be easier to consume, if it was standardised across the device types. Instead a different export format is currently used for each device type, this increases the amount of work that must be done to make use of the data.
- Completing the entry of the meta data required to export the data in the necessary format for the IBM DGA aspect of the project proved very time consuming. Unfortunately the provider of the data analytics tools had not been selected at the time the database was configured, had this requirement been anticipated at the start of the project, it would have been much more efficient to capture this information in the format needed by IBM as part of the initial site commissioning.
- The visualization (mimic) feature in iHost has become a very valuable tool in the equipment commissioning process for validating that equipment has been installed correctly.
- The practical experience of monitoring different types of devices has allowed historical data transfer capacities to be quantified. This has informed the specification of equipment (for example, SIM cards) in downstream projects, most notably the SPEN LCN Fund Tier-2 project “Accelerating Renewables Connections”.
- This project has demonstrated that iHost can be used successfully, reliably and cost-effectively for the integration of a number of disparate systems and equipment types.

10. Planned Implementation

The communications infrastructure and data collection platform originally engineered for the FlexNe project is being retained by SPEN to provide data collection functionality to the Accelerating Renewable Connections (ARC) project.

SPEN are currently considering their requirements for substation monitoring to be deployed during the RIIO ED1 period, the system as it stands would be well places to collect the data from these devices as they are deployed in the field.

An iHost server has also recently been deployed within SPEN, with links to the Power On Fusion Distribution Management System, if substation monitoring equipment were communicating with this server, the data could be made available to control engineers in real time, to assist with network operating decisions.

iHost as a product is being continually enhanced to allow it to cope with ever larger volumes of data, and provide improvements to the tools and interfaces that allow users to work with the data stored within it. Already today it has been shown to be suitable for projects with larger numbers of monitored sites, more data points, and higher reporting frequencies. In the future it will be suitable for very large scale business-as-usual applications.

11. Facilitate Replication

In order to facilitate replication of the monitoring and data hosting capabilities demonstrated in FlexNet, the following sections include a functional description of iHost, a replication methodology and the contact details for staff at Nortech. This information could be of particular interest to any DNOs or other stakeholders that have equipment monitoring, control or automation requirement or have a need for data transfer, data hosting and automated analytics solutions.

At the heart of Nortech's monitoring solution is iHost – a system which is already utilised to a greater or lesser extent by each of the UK DNOs. This makes the FlexNet monitoring solution, and the list of currently supported devices for monitoring, readily transferrable to other DNOs.

11.1. Functional description of iHost

iHost has five primary functions:

1. Data concentration: iHost currently supports a number of equipment types, as summarised in Figure 6, concentrating the data from these devices into a repository with dual-redundancy.

2. Protocol conversion: Downstream of iHost, the system supports a number of standard and proprietary communication protocols including (but not limited to): DNP3; DNP3 secure; HTTP; HTTPS; FTP; FTPs; eMS; Gridkey MCU; Landis and Gyr; Horstmann; Nortroll; Kehui; Outram; Bowden; and many more. Upstream of iHost, the system supports standard communication links into DNOs' Network Management Systems, such as DNP3, IEC 60870-5-104 and IEC 60870-5-101.

3. Population management: This function of iHost allows the user to remotely configure field devices, capturing site-specific information (such as geographical coordinates) and associating it with the devices in a unique way.

4. Data historian: This function of iHost allows large volumes of data to be archived and available for retrieval at a later stage. An example of the growth in historian capabilities is summarized in the table below. In addition, data can be made available in a variety of different formats for post-processing (such as CSV files for MS Excel).

5. Data visualization: Data can be visualized in iHost in a number of ways: tabular format; interactive trending; and mimics of the physical system.

Nortech is continually developing iHost and its capabilities. For further details on iHost and its latest capabilities, please contact one of Nortech's delivery team as detailed in Section 11.3.

Reference case	Data requirement
Typical primary substation feeders (current BaU)	700m readings a year
NPG's Customer-Led Network Revolution (LCN Fund T-2)	1.1bn readings a year
SPEN' Flexible Networks for a Low Carbon Future (LCN Fund T-2)	7bn readings a year*
ENW's Customer Load Active System Services LCN Fund T-2)	42bn readings a year*

* iHost solution utilised for this volume of data

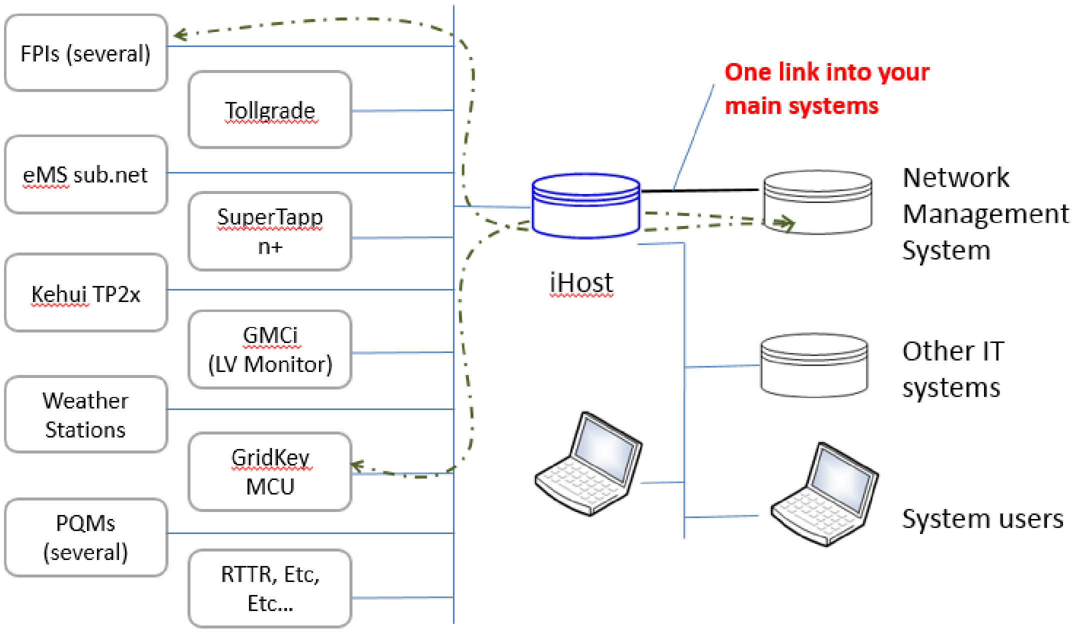

Figure 6 – Field devices 'concentrated' by iHost

11.2. Replication methodology for the Flex Net monitoring solution

The replication methodology for the Flex Net monitoring solution is outlined below:

1. Evaluate the monitoring needs of their project, how many devices, what parameters each device will monitor and how often each value needs recording;
2. Use the information in (1) to specify data hosting capacities and data transfer requirements (particularly for SIM cards);
3. Identify a secure location to host the servers, with good network connectivity and resilient site services (cooling and power);
4. Procure a private GPRS APN, with one or more GPRS networks;
5. Implement the connectivity from the APN to the server hosting location;
6. Put in place the necessary expertise to install and commission any required software (e.g. iHost, and any additional 3rd party software)

7. Put in place the necessary expertise and experience to provide the required technical support, to respond to system monitoring alerts and diagnose issues raised by users of the system