Smartly Maintaining Dublin's ITS Infrastructure

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Abstract

Nicander have recently completed the development of an Internet and smart phone-based integrated fault, repairs and inventory management system commissioned by Imtech Traffic & Infra for Dublin City Council and third party maintenance contractors, including Imtech. The system is used to manage the fault lifecycle of all ITS equipment in Dublin. By providing the ITS field staff with access to the system directly from the smart phone in their pocket, we are able to deliver the following benefits:

- Ability to respond quickly to faults and avoid downtime to ITS infrastructure.
- Eliminating wasted travel time, minimising travel costs & carbon emissions.
- Optimising maintenance team size and utilisation.
- Removal of time and space-consuming paper-based procedures.
- Maximising first visit fault rectification and optimising repair activity.
- Single data entry with real time equipment status.
- Infrastructure is maintained to the highest standard.
- Effective identification, classification and prioritisation of faults/repairs.
- Facilitates the identification of poorly performing technology and root cause analysis.
- Facilitates improved stock control and optimal spares holding.
- Time consuming fault/repair recording tasks are automated and all activity is fully logged.

System Objectives

Dublin City Council is the largest local authority in Ireland. One in four of the Irish population live in or around Dublin, necessitating the need for an effective transport infrastructure. Dublin has invested significantly in ITS over many years, including the installation of SCATS in 1989, through a comprehensive programme of CCTV, automatic number plate recognition, vehicle detection, emergency telephones, access and lane control, variable message signing installations, and this investment today plays a critical role supporting economic growth throughout Ireland through the delivery of an efficient and safe network, and ensuring the availability of this technology is a core objective. The Dublin City Council Fault Management System is used to manage the fault life cycle of ITS equipment maintained by in-house staff and third party contractors throughout the region to optimise equipment availability. Faults are diagnosed automatically through system interfaces to monitor the roadside devices.

Management services are delivered through internet based connectivity including mobile applications to facilitate service delivery to the Authority and aid its traffic equipment maintenance in a real time field based environment.

Access to the system is securely available from smart phones to allow field engineers to view and enter all necessary and the latest information directly from the roadside.

The aim of the system is to optimise the availability of client ITS infrastructure throughout the region to reliably support all information and control services and minimise service support costs. By detecting, logging and notifying users and companies of faulty ITS infrastructure, action can be quickly taken to rectify problems and minimise equipment downtime. The system includes inventory management capabilities to enable the effective management of all field based equipment. The implementation of the system includes a contract specific asset management / inventory facility with an associated mobile device for Android implementation to allow inspection reports to be carried out remotely.

The system enables the Authority and its contractors to effectively plan all routine maintenance tasks, whether recurring or one-off, and enables real time completion of inspection reports, improving the health of the infrastructure, staff utilisation and operational efficiency.

Mark Horgan – Imtech Business Manager – Ireland:

"The changeover and migration of data from the old FMS system to the new FMS system was professionally managed by the Nicander team, providing a seamless transition. The benefits of the new system are many: ~ the browser-based interface provides access from both the office and the field and is very intuitive; users have noticed significant improvement in application response; many new features have been added to the new system including planned maintenance scheduling. The FMS system provides a new insight into the management of all our maintenance activities and this will result in greater efficiencies and a higher achievement of KPIs."

Scalability and Accessibility

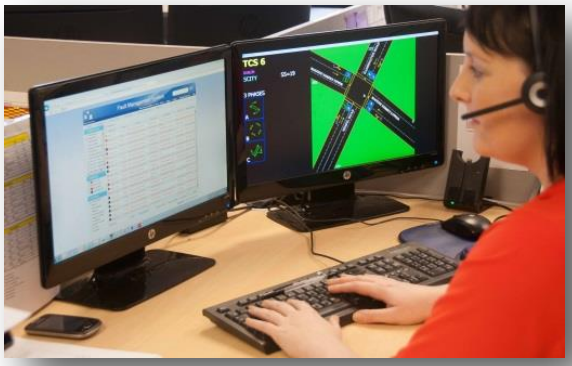
Core requirements for the system are scalability and accessibility. As the system is web based it is accessible from anywhere and by any authorised user with access to the internet, including running on tablets and smart phones.

The system has been designed to easily cater for increases in the numbers of equipment and types of contract. Its open architecture enables safe and secure accessibility to authorised third parties in terms of third party equipment, access to system data and the ability to run the client on multiple platforms.

The system servers are deployed in a virtual VMware infrastructure, conform to open industry standards and use VM facilities to provide high availability operation; it operates within a secured website using industry best practice, and utilises the latest in mobile phone and tablet

technologies for real-time connectivity and operation. Its features include fully customisable reporting and rules for sending alerts by email and SMS. Multiple web browsers are supported.

Multiple Stakeholders



The system delivers services to multiple client staff, contractors and other stakeholders as part of a fully integrated online service. The web access is configured and encrypted for secure web access using multiple browsers.

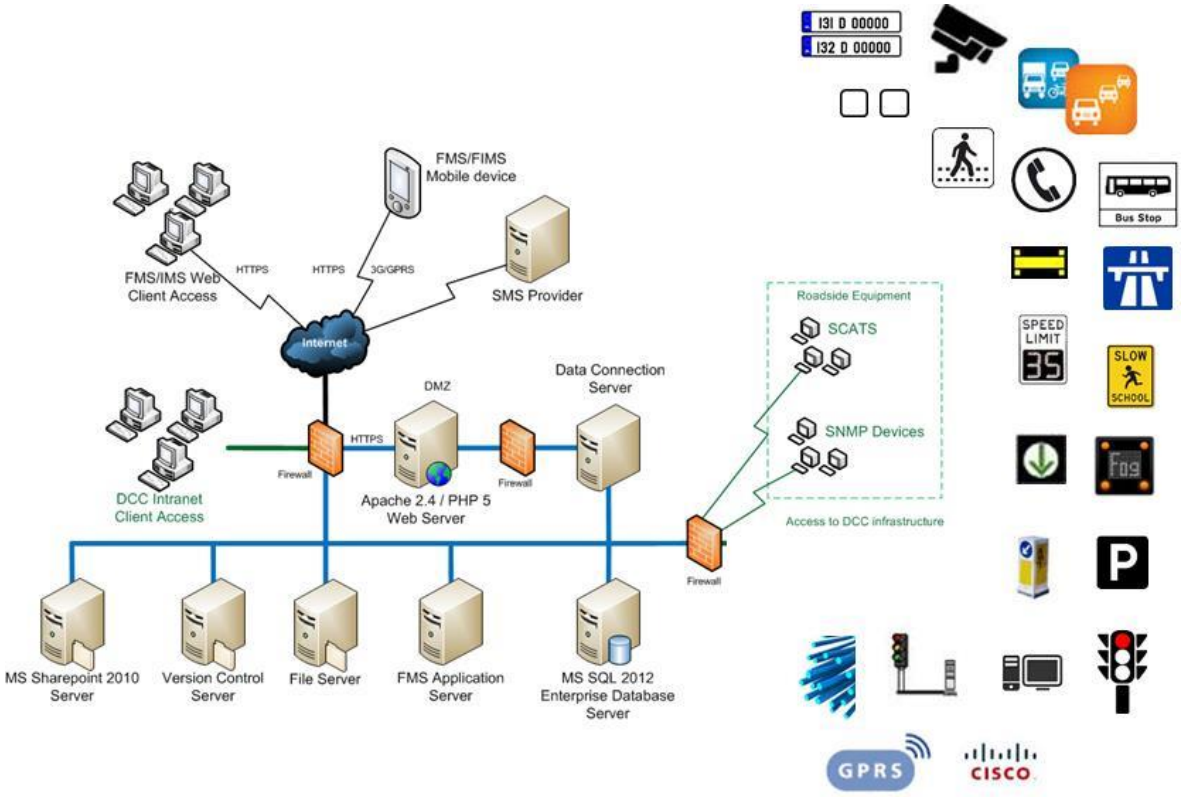
The system includes mobile applications to facilitate effective service delivery, supporting field technicians in a real time manner, with all facilities at their finger tip, providing managers with a real-time view of equipment status and repairs. The user interface is simple to use and as intuitive in nature. As the application is developed for Android Smartphones, we are easily able to port the application to a number of different handsets from different manufacturers, enabling the support of a range of devices agreed with DCC and its stakeholders. This strategy also limits the amount of new development necessary when newer versions of the Android Operating System are released.

Multiple Equipment

The system delivers an effective management service covering an extensive array of ITS technologies throughout the Dublin network. Faults can be raised manually or automatically; it is directly linked to numerous external third party ITS systems for fault information from over thirty different infrastructure types.

The system delivers an effective management service covering:

- Traffic signal sites, in the city and throughout the region.
- Traffic and incident detection equipment including ANPR and video incident detection, CCTV, Axel and various loop-based counters, above ground detectors, tunnel monitoring and control equipment, emergency and standard telephones.
- Variable message sign systems, including parking guidance, RTPI, school warning, speed, lane control and general information signs.
- Central computer systems and communications equipment, including SCATS central and regional computers, fibre and GPRS comms equipment, various routers and switches, and a variety of test equipment.
- Other infrastructure including access control equipment, rising and illuminated bollards, gantries, uncontrolled pedestrian crossings.



Managing and Logging all Faults

A fault in the FMS system exists in a number of different states and it is only able to live in one of these states at any one time and follows a logical flow through the process:

- Raised
- Acknowledged
- Attended
- Fixed and Cleared
- Re-instated
- Request to transfer
- Request On Hold
- Transferred
- On Hold
- Cancelled

When a fault changes from one state to another all configured users and managers are notified appropriately; this is configurable based on the fault, its classification, priority and the equipment type. This is managed by the system against a comprehensive set of priority based rules, which may be applied globally across the system or specifically depending on a particular fault.

To enable users and managers to understand the long term trends on equipment performance, faults will be displayed for five years, which is configurable, until archived from the system. Facilities are provided to provide ease of navigation through the system and the presentation of information in a succinct manner to enable fast and effective diagnosis.

As the system uses smart devices operating in real-time and a single entry by the user, combined with the use of standard smart phone facilities, the fault timeline is more effectively managed by the system.

Planning Maintenance and Works Orders Effectively

The system provides facilities for the effective management of all planned maintenance activities and works orders. These exist in one of the following states:

- Un-Acknowledged (Scheduled)
- Acknowledged
- Attended
- Fixed and Cleared
- Cancelled

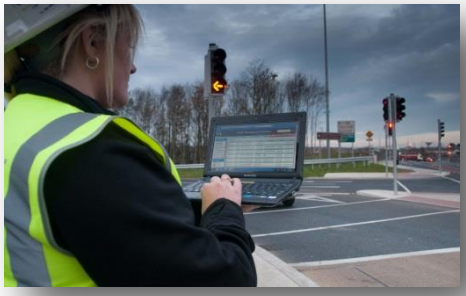
The system supports the effective scheduling of all planned maintenance activity. Planned maintenance and work orders are scheduled for once only activities at a specific time and date, and for planned maintenance it is possible to set the schedule to re-occur.

Planned Maintenance and work order notifications can be configured to be sent when changing from one state to another and when planned maintenance is acknowledged. Priority rules defined within the system manage the delivery of all notifications to ensure users are alerted appropriately. Every notification that's sent will result in the message along with the associated recipient list being logged in the database.

Secure Access

The client end of the system is made available over the public internet and therefore security against web based attacks is essential. Our solution:

- Encrypts web client traffic using Secure Socket Layer (SSL).
- Sanitizes and validates user inputs for errors to prevent any possible SQL injection or cross site scripting (XSS) flaws.
- Checks user access privileges on every web page to remove the possibility of bypassing the credential checking process.
- Uniquely regenerates user session identifiers upon user login.
- Associates the user session identifier with the user IP address to prevent the possibility of hijacking the user's session.
- Applies Apache and PHP default security settings in the customer's environment.
- Obfuscates user password inputs on the web pages.
- Stores in the database all passwords encrypted using MD5 hash.



Access rights defined within the system manage the specific roles and responsibilities of all staff; access privileges are assigned to users using groups, where a group will contain one or more access privileges. The user can belong to multiple groups and will inherit all privileges from all groups that they are associated with.

Access to the system from both a desktop browser or from the mobile applications require authentication using a unique username and password; encryption is performed using an MD5 algorithm. All communication from the client to the server will use the MD5 encrypted form of the password and this communication will be further protected from packet snooping software by using SSL for all communication. A password reset option is provided which allows a user to specify their registered email address to receive a reset password.

Data Configuration

The system provides a data configuration portal web user interface, which is accessible to a defined group of administrators, and is used to view and edit the configuration data used within the fault management system. Users of the portal can easily:

- add new equipment
- add a new company
- add an association between a company and a piece of equipment
- edit types of alarms to be reported to the company
- edit rebate periods
- edit DCC personnel to be contacted
- edit access rights for users

Effective Reporting

Microsoft SQL reporting Services 2012 provides the main reporting capabilities of the system. This delivers effective facilities to view reports on screen and print these reports using the operating system provided printing facilities, and to export the reports into XML, CSV, Excel and PDF formats. The system incorporates a comprehensive scheduler to enable effective report creation into specified dates and times of interest. Because the system manages multiple equipment types across multiple contractors and suppliers, the system manages all report creation and viewing to ensure only authorised users can view specified reports.

A scheduled report can be emailed to a list of email addresses that can be configured when setting up the report schedule and can be scheduled to reoccur periodically, allowing daily, weekly or monthly schedules.

A monthly report is created showing key performance indicators; these are automatically calculated by the system and presented in the report.

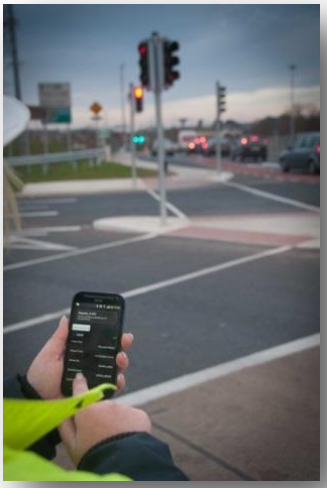
Configuration forms are provided to easily adapt the presentation of the reports in the system to suit operational issues and business needs.

As part of the system, a web service is provided that can be used by third parties to develop custom applications for accessing system information.

System Performance and Reliability

The technology platform comprises the following server components:

- Web Server
- Database Server
- Application & Notification Server
- Document Management & Version Control Server
- File Server



Each server is deployed with a specific purpose to provide isolation at the operating system level allowing CPU, memory and disk capacity to be tailored for the server component.

The above servers are provided as virtual machines configured to run in Dublin City Council's existing VMware ESXi 5.1 vSphere v5 infrastructure. The high availability feature of VMware vSphere Enterprise Plus ensures optimal performance levels are achieved.

This architecture will easily allow the upgrade of servers at a later date should the need arise.

The web server runs Apache and PHP, allowing the use of Transport Layer Security (TLS) / Secure Sockets Layer (SSL) to encrypt web client traffic and the provision of a new web client to run under many web browsers including mobile base web browsers.

The database server - SQL Server 2012 enterprise edition – is used to provide the following capabilities:

- It is an ACID compliant database which supports full point in time database recovery and provides its own native backup and restore capabilities.
- A SQL Server management studio which is an integrated tool providing features for monitoring, reporting and analysis of the SQL server performance.
- Support for the Open Geospatial Consortium (OGC) standard for spatial databases.

Design, Installation and Testing

The system was developed using a collaborative approach, with the client and key maintenance contractor being involved throughout the development lifecycle. Together, the user interface and workflow were designed using prototyping as a means of promoting discussion between all key stakeholders. This was particularly important given the multiple organisations and individuals that would be using the system. As a result we were able to quickly design and modify the system as the practicalities of the initial requirements specification became fully understood by all parties and as they were tweaked and fine-tuned by the client and dovetailed with the new operational procedures. This alignment of system and operational process was a continual

process of collaborative improvement to ensure all benefits of the new system were fully attained.

With the system being deployed in a virtual environment this gave the opportunity to install the system very early in the programme, to provide access to system facilities and features to provide an early opportunity for stakeholders to comment and discuss aspects of the system. This collaborative approach allowed the client additional time for establishing all business processes, training and education, and fully prepare the system for operational running.

Traditional factory testing would normally be undertaken on our premises before installation of the system in its intended location. But by delivering the virtualised system early we were able to undertake acceptance testing at the customer's site giving improved access to all staff resources in the real environment to ensure each test was more comprehensive and completed in an efficient manner. With all key client staff being involved in the acceptance test process this also provided greater confidence in the system's fitness for purpose.

The system has been designed and implemented using techniques which aim to minimise the risk and effort required when making any future modifications to the system allowing the system to be more easily adapted to meet any future needs.

Conclusion

The new system went live on the 14th of January 2014. There was a smooth changeover and migration from the old system to the new management system, including historical fault and equipment data to ensure a seamless transition.

Training staff in the use of the new system has proved very effective. The browser-based interface is very intuitive and all users have taken to the new system very easily and are quickly able to navigate through the system and utilise all the new features to deliver operational improvements from day 1 of operation. Already, the users of the system have noticed significant improvement in application response. Engineers are noticeably clearing faults more quickly as they have fast access to all the latest and correct information they need on a single smart device, resulting in safer and more efficient site work. The intuitive interface is enabling engineers to clear faults more quickly in a consistent manner and single data entry is improving staff utilisation.

A key benefit of the new system is the quality and accessibility of equipment performance data from which operators, managers and contractors can tailor their views of the system and reports generated to best suit their needs. Improved access to historic data is enabling the implementation of pre-emptive strategies to increase equipment availability.

The system is providing new insight into the management of all maintenance activities to better coordinate repair tasks and deliver improvements in productivity. By providing a real-time view on the status of the network equipment and contractor performance, the Authority and its contractors have the right information at their finger-tips to ensure its operational staff are able to better respond to incidents and ensure Dublin's traffic is better managed through the improved availability and use of its roadside technology.

The Client Operations Manager is already seeing the benefits of being able to easily and quickly tailor reports to identify weekly trends in equipment performance allowing him to identify and investigate poorly performing assets and identify the root cause of why certain equipment is failing. In the first two weeks of operation, a number of critical issues were identified and works

orders raised to implement targeted equipment maintenance strategies to resolve these issues and prevent future faults occurring.

A key new feature identified by the Client Operations Manager as delivering significant benefit after the initial weeks of operation is the notification feature. As the client is concerned with 24x7 operation of Dublin's ITS infrastructure, when managers are away from the office they are able to receive tailored real time messages to notify of changes to the state of all equipment managed. The system is able to be configured to alert senior managers and key stakeholders via email and SMS against pre-defined criteria; operators can also easily define alerts to notify key personnel regarding changes in fault status. The flexibility of the system also enables the client to alert specific members of the general public (such as registered disabled/blind) where certain locations and equipment may significantly impact them if equipment is not working.

By providing higher quality focussed around contract KPIs across all ITS technologies to both the Authority and its contractors in a consistent manner, it is anticipated that the alignment of information will very quickly optimise the performance of the technology, staff and the network to delivered improved service to the travelling public in and around Dublin. The feedback from all stakeholders on the performance of the system over this initial period of operation has been very positive and the confidence that the system will fulfil all objectives is very high.

By using an open architecture, standard internet connectivity and smart phone technologies future emerging technologies can more easily be quickly integrated into the system to improve service delivery as well as the integration of new and additional roadside technology systems. Improvement opportunities will be continually reviewed against Dublin's strategic objectives and commitments to ensure the system continues to play its key role ensuring Dublin's smart infrastructure is available to make everyday life easier in Ireland.

Acknowledgements

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1. Nicander DCC FMS 4595-005 Functional System Requirements.
2. Nicander DCC FMS 4595-012 System Design Specification.