AN XML-BASED MOBILE APPLICATION FOR DISTRIBUTION NETWORK MAINTENANCE INSPECTION

Janne TOIVONEN
Tampere University of Technology
Institute of Power Engineering
Finland
janne.t.toivonen@tut.fi

Aimo RINTA-OPAS
Koillis-Satakunnan Sähkö Oy
Finland

Pertti JÄRVENTAUSTA
Tampere University of Technology
Institute of Power Engineering
Finland

ABSTRACT

Compared to traditional maintenance inspection with paper sheets, electronic maintenance data collection can improve maintenance data management. At present maintenance inspections are outsourced in many companies, and hence the mobile solution should support outsourcing, too. One challenge is how to manage the data exchange between mobile applications and other information systems in distribution utilities. This paper describes a demonstration of a mobile inspection application that connects to a network information system database by using eXtensible Markup Language (XML) transfer files.

INTRODUCTION

Distribution network maintenance inspection is an operation that requires a lot of man-hours. At present inspection work is outsourced in many companies. Traditionally the maintenance data has been collected with paper sheets, and if information systems have been used for maintenance data management, inspection records have been fed manually to databases. Mobile applications are needed for electronic collection of maintenance data, and as well for other field tasks of distribution utilities.

Mobile technology has been developing rapidly but mobile solutions are still not yet common in electricity distribution business. Nowadays electronic data collection is typically performed by using a network information system (NIS) with a laptop computer. More simplified applications and compact mobile devices would be more practical for inspection activity. Applications should also be independent of other information systems in a distribution utility to support outsourcing of maintenance inspection. The biggest challenge with developing this kind of independent mobile applications is how to access the required information in NIS and other systems when no proper interfaces are available for data exchange.

The purpose of the research was to demonstrate an XML [1] data transfer between a NIS database and a mobile application. A PDA (Personal Digital Assistant) software was developed for collecting maintenance data. Also a connection program was created for generating XML files from the database and for storing the collected maintenance data into the database. The developed demonstration solution is described in this paper. Also overall needs for mobile applications at field crew level operations are discussed.

The study is a part of a joint project [2] of Tampere University of Technology and Lappeenranta University of Technology concerning the development of electricity distribution business.

Short introduction to XML

XML is a flexible text format that can be used for example for sharing information among different applications. It is a markup language that looks much like Hyper Text Markup Language (HTML) but they are designed for different purposes. XML can be used for describing information, whereas HTML is designed for displaying information. And first of all, instead of predefined tags as in HTML, users define XML tags by their own. Also the structure of an XML document can be freely designed. An XML document is like a database in text format because XML documents consist of nested elements that have relationships. [3,4]

The following example is a simple XML document that contains information about network components:

```xml
<?xml version="1.0"?>
<Components>
    <Transformer ID="248020">
        <Type>KTMU-24X2635</Type>
        <Rating>100</Rating>
        <Voltage>
            <Primary>20000</Primary>
            <Secondary>400</Secondary>
        </Voltage>
        <Inspected>2001</Inspected>
    </Transformer>
    <Disconnector ID="25400">
        <Type>NPS</Type>
        <Operation>manual</Operation>
        <Inspected>2001</Inspected>
    </Disconnector>
</Components>
```

XML in distribution utility information systems

XML is not very commonly used in distribution utility application integration but some literature on the subject can be found. The best-known XML-related solution would probably be the Common Information Model (CIM) which is an International Electrotechnical Comission (IEC) standard for integration of electric utility information systems [5]. The reference [6] discusses possibilities of XML and describes a prototype XML application for electricity market transactions and for utility database data exchange. XML is also used for linking data in two separate applications of an asset management software [7]. The reference [8] introduces an application for interpreting Geographic Information System (GIS) data for network management systems that operate and control the distribution system.

DESCRIPTION OF THE SOLUTION

The operating principle of the demonstrated solution is illustrated in the figure 1. The XML file is used as an electronic inspection form that contains all the necessary information about the inspection and it's components.

1. The adapter software creates an XML file containing inspection plans and network component information.

2. The XML file is transferred to the PDA device.

3. Collected maintenance data is saved to the XML file.

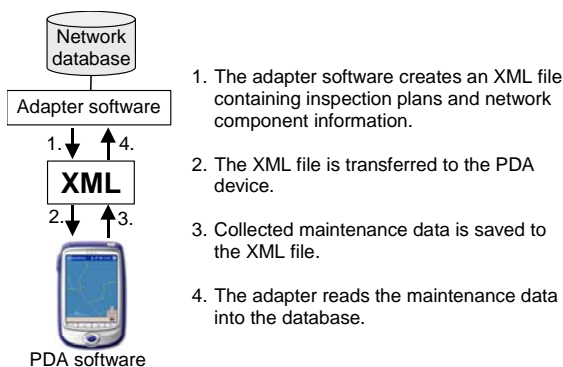4. The adapter reads the maintenance data into the database.

Fig. 1. Operating principle of the solution

The mobile application is independent of information system vendors and database structures, and it is compatible with different company specific maintenance practices. The flexibility of the solution is based on freely nameable XML tags and hierarchical document structure.

XML structure

The content and structure of the XML files were not strictly specified to keep the solution as flexible and versatile as possible. Only a certain six-level hierarchy was defined for the XML structure but the XML elements can be freely named in any language. Clearly named nested elements describe the data being transferred. Condition information of a distribution substation could be structured for example by the following XML fragment:

```
<Distribution_substation>
  <Pole_mounted>
    <Condition_data>
      <Transformer>
        <Tank>
          <Rating>0</Rating>
          <Info></Info>
        </Tank>
        <Insulators>
          <Rating>2</Rating>
          <Info>cleaning needed</Info>
        </Insulators>
        ...(continues)
```

The actual data is the value of the sixth (innermost) element and the upper elements identify the data. Basic information of network components or any other information can be transferred similarly in the same XML file.

From the PDA application's point of view, it doesn't matter what is the content of the XML document as long as the six hierarchy levels exist in the XML. However, the elements must be named in such way that the user of the PDA application can easily read the information. The intelligence of the whole solution is in the XML files and the PDA application itself is only a simple tool for browsing and inputting data.

The structure of an XML document can be defined with XML Schema, also known as XML Schema Definition (XSD) language. XML Schema is typically a separate XML file and it can be used for example for checking the validity of an XML document. In this solution XML Schema is used for defining allowed values for components' condition ratings and using these values as multiple-choices to make data entry easier for the user.

Database connection software

A database adapter program was created for connecting the inspection application to a real commercial NIS database. The adapter generates XML files for the PDA application and stores the collected data from the returning files into the database. In this solution XML file is used as a form, which is filled using the inspection application, so input and output files have exactly the same structure. The files are transferred between an office PC and the PDA by a connection cable.

The adapter was programmed using the Microsoft .NET Framework, which provides number of pre-coded solutions for processing XML. The adapter was created for demonstration purposes but in the real life information systems itself should provide the support for importing and exporting data in XML format.

PDA application

The maintenance inspection application was developed for a Pocket PC PDA device using the Microsoft .NET Compact Framework. The application is designed mainly for displaying network components' basic information and for collecting maintenance data of components. Figure 2 illustrates the touch screen operated user interface of the PDA application.
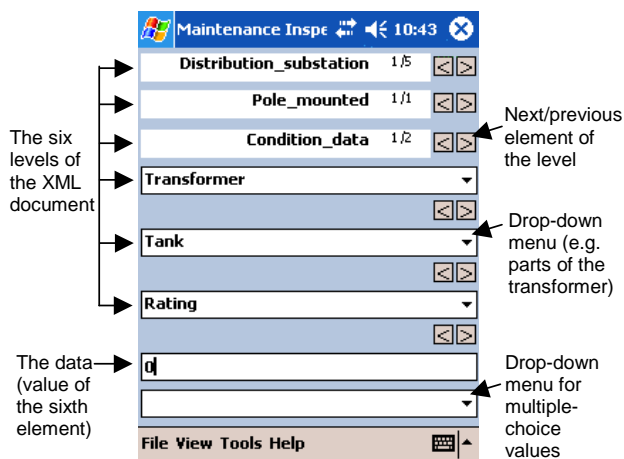

Fig. 2. User Interface of the Application

The figure 2 displays the same information that was presented in the previous example XML fragment. The application simply displays every XML element in corresponding field in the user interface. The principles of the programming methods of the application are presented in the figure 3.

The inspection application can also be used for displaying network diagrams, e.g. a low voltage network diagram. Coordinate data for the network diagrams is transferred in the same XML documents with all the other information, but a certain data exchange structure was defined for this purpose.

Test results

The concept was tested for inspection of pole-mounted distribution substations in one distribution company. The XML structure of the transfer files was designed based on the paper sheets used in the real inspections. The database adapter program was installed in a workstation computer and a copy of the company's network database was made for safe testing.

The solution proved to be suitable for efficient electronic data collection and storing. The specified XML format is flexible and it can be used for different purposes with the same version of the mobile application. The application supports also outsourcing of maintenance inspections. A service provider could use it's own mobile application with every distribution company that has an information system with the specified XML interface. Presently service providers usually use customer's computers for data collection.

FIELD CREW LEVEL APPLICATIONS

Maintenance is not the only operation that needs mobile software tools for field crews. Mobile applications would be useful for example for fault repairing or field planning tasks. These field tasks are usually suitable for outsourcing, too. Mobile applications are also needed for field crew management.
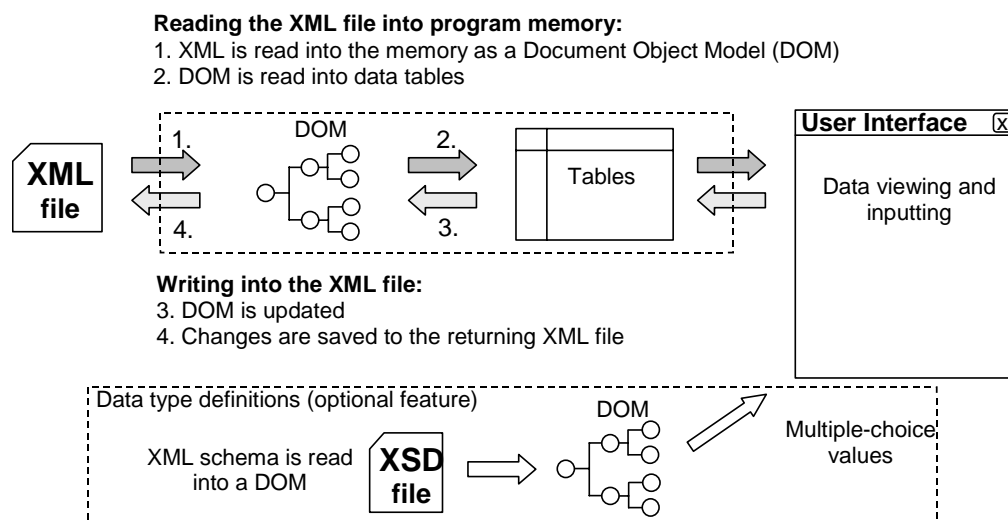

Fig. 3. Operating Principle of the PDA Application

Mobile applications need information, such as network maps, fault localization results, component data, switching state of the network, calculation results, and e.g. land register information from several information systems. A common need for field crew applications is navigation by Global Positioning System (GPS) to find the target. Field crews could also use mobile applications to update component information or network plans.

Since a simple application may need connections to several data sources, data exchange interfaces are crucial for development of mobile applications. It is possible to develop either several separate applications for different purposes or integrated overall systems with standard interfaces (e.g. a NIS with extensions for field tasks).

Also a suitable mobile device is naturally needed for the software application. Depending on the field task, the device can be a laptop computer, tablet PC, PDA or a smart phone. The most important property of a field crew application is usability, e.g. use by one hand.

CONCLUSIONS

Collected maintenance data has traditionally been filed only in paper files or data has been fed manually to database systems. Electronic data collection applications with automated database storing can improve maintenance data management. Present mobile technology is quite advanced but few mobile applications are available for distribution utilities. In addition to maintenance, mobile applications would be useful in any field task. Development of mobile applications requires open interface standards for accessing various data sources and these standards should also be implemented in utility information systems by systems vendors.

At present outsourcing is quite common in maintenance inspection, as well as in other distribution business operations too. So applications and interfaces should be suitable also for outsourced operations. Service providers need applications that are compatible with different information systems used by their customers.

The aim of the research described in this paper was to demonstrate an XML-based data exchange method for a

mobile maintenance inspection application. The demonstration consists of the database adapter program, XML transfer file specification, and PDA application. The objective was to design an outsourcing supporting mobile solution that can be used with different distribution companies and different information systems. Flexible and versatile XML proved to be a good technology to be used as a basis for data exchange between mobile applications and other utility information systems.

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