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NePESM: New Paradigms for Embedded Systems Management

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1. Aim of the Project

Embedded system management (e.g. remote management of power station, trains, or buildings) is becoming an important marketing tool for equipment providers. Large equipment providers (like ABB, Landis & Gyr) or small companies that sell manufacturing equipment need to deliver and prove, to their customers, solutions with a low total cost of ownership. In many cases, they also need to run and maintain the equipment for their customers and share the savings made by a more efficient operation.

The goal of the NePESM project is to identify, experiment and validate new paradigms (and their supporting software systems) applicable to the maintenance management of distributed embedded systems. The NePESM project develops the core expertise for remote management of embedded systems using Internet technology. The main requirements addressed are:

- **Zero-cost client configuration**: we develop communication architecture for distributed embedded systems, targeting zero-cost client configuration.
- **On-line data analysis**: the system should provide a data warehouse supporting the integration of the information coming from the embedded system. It should provide tools for data analysis as well.
- **System architecture**: the project should provide a guideline on how to design-in remote maintenance with a prototype demonstrating the concepts.

2. Main Results: the RoMain Application

In the scope of the NePESM project, we developed, in collaboration with ABB Corporate Research and the Railway Open System Interconnection Network (ROSIN) European project, a web-based monitoring tool for trains that supports maintenance work. This tool was called Railway Open Maintenance tool (RoMain). The application of this tool is to get access through the Internet to current train data, using nothing but a standard web browser. This is graphically shown in Figure 1.

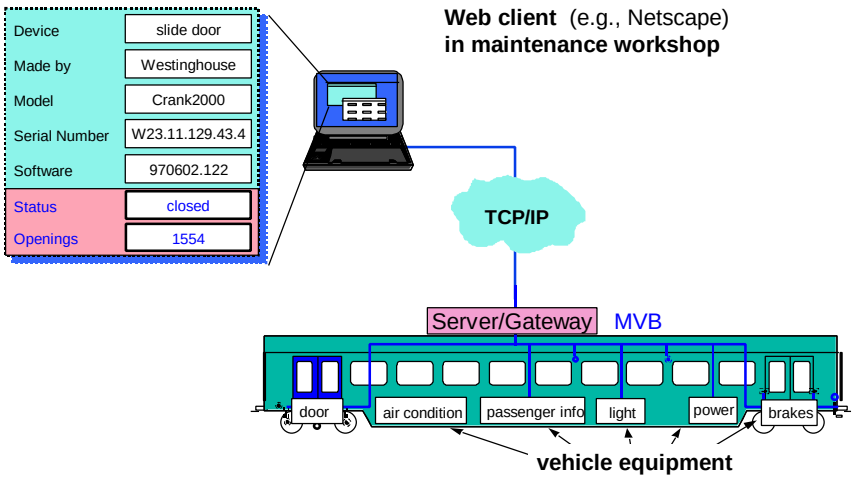

Figure 1: The RoMain Application

The kernel of this tool is a data acquisition system, developed in Java, which is installed on-board a train. This data acquisition system is based on the experience of GLASS [Itschner et al. 98], a general purpose monitoring system based on Internet technology.

The RoMain tool **API** covers all the main **functional services** defined by the OMG Data Acquisition from Industrial Systems RFP [OMG 99]:

- **Discovery of Remote System and Device Schema:** it offers mechanisms for discovering accessible remote devices and measurements.
- **Data Access / Retrieval**: it includes mechanisms for retrieving data immediately upon request.
- **Defining Data Access Requests:** the set of data to be requested is predefined by the full set of properties of each device.
- **Event Notification for Availability of Data:** it enables broadcasting events outside the industrial system to which clients can subscribe in order to receive a notification when new data is available.
- **Event Driven Data Upload:** data delivery is automatically done upon the occurrence of a notification for availability of data.

Moreover, the following **non-functional features** were a plus in the deployment of such application:

- **Portability**: this was achieved by the use of Java as a programming language. As Java is independent of a physical machine, the server can be installed on any platform running a Java Virtual Machine (JVM).
- **Extensibility**: this was achieved by the use of self-described data. This data is formatted using eXtensible Markup Language (XML), which is the new standard for exchanging of data over the **Internet.**
- **Low cost**: the low cost of such a monitoring system was one of the most crucial requirements. It is mainly achieved by the use of COTS (Component Off-The-Shelf) Internet technologies, and by the use of the already existing Internet communication infrastructure

The main results from this project are **three different demonstrations**:

1. Simple monitoring of an air-conditioning system based on commercial **proprietary client-server communication technology** (@aGlance/IT).
2. Monitoring of a full train based on an **object-oriented middleware** (JavaRMI).
3. Monitoring of a full train based on **exchange of documents** (based on XML/XSL technologies).

The demonstrators are focused on the interconnection technologies and they did not address on-line analysis. They can be seen at http://icapc62.epfl.ch/nieva/romain.htm.

3. Conclusions

The main conclusion from this research work is that **"Internet technology is the right choice for time non-critical remote monitoring applications"**. Other conclusions are:

- **Information modeling**: information modeling of the industrial system is the basis for building a "*plug&play*" communication architecture
- **System architectures**: we experimented with three different architectures. The XML based solution has higher performance and it is much more flexible than object oriented solutions
- **Extensibility**: appliances are associated to proxies. Implementing monitoring support within proxies, rather than within appliances, enables flexibility in evolution.
- **On-line analysis**: OLAP tools can certainly help the users in better exploiting and understanding technical and maintenance data

4. Technology and Know-How Transfer

The close collaboration with **ABB Corporate Research** has made possible the fast transfer of technology and know-how from the university to the industrial world.

We participated in the **ROSIN European project**, which was formed by several of the most important European railway companies and manufacturers. In the scope of this project we developed the RoMain application and we contributed to the Train Communication Network standard. One of the most impressive results of this project was a demonstration, which was made in February'99 in Bilbao (Spain), with a real train equipped with equipment from heterogeneous manufacturers.

A technical article [Nieva 99Nieva 99Nieva 99] was presented at the **17th IASTED International Conference - AI'99,** which took place in February'99 in Austria. This article explains the automatic configuration process followed by the RoMain data acquisition system, which enables "*plug&play*" of devices. A publication describing the RoMain system will be presented in the **Rail Technology'99** conference, which will take place in September'99 in London. At this conference a demonstration of the application will also be shown. We are currently working on a journal publication that gives some patterns on remote data acquisition systems illustrating them through the RoMain implementation.

Potential applications of the results of the NePESM projects are **web-based remote monitoring applications** of any kind of industrial system, like power sub-stations, buildings and so on.

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