Portable Process Control with DynaControl

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Abstract

Remote controlling of industrial systems requires a special approach. There are requirements for both the connection and the access terminals. The connection should provide users with reliability, security and quality, and the access terminals should be able to perform the required task. One important and at the same time a problematic requirement for a mobile controlling system is bidirectional access. In this paper we describe a system which enables bidirectional data access within 3G cellular network using a commercial service, and a prototype application for quality and usability for task performance using a terminal recognizion methods.

1. Introduction

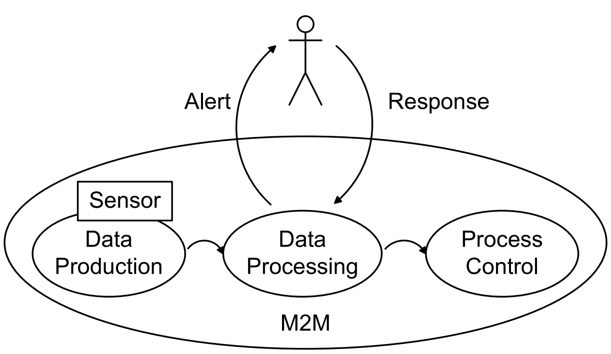

Figure 1. Machine to Machine system in a Process Control Environment.

Traditional process control systems are very static and located mostly control rooms within the factory premises. The persons monitoring and controlling the process cannot even leave to the factory floor, let alone be on the other side of the world. In general, process control systems usually consist of four parts. First, the actual process unit, for example a sensor node, gathers data from the process and transmits the data to the data processing unit (DPU). Operators can monitor the system by fetching data from the DPU and control the system by sending commands to the DPU. Based on sensor input and user commands, the DPU controls the process. Figure 1 presents the logical form of a generic machine-to-machine process control environment.

At the same time the importance of mobile computing has increased, and mobile phones as well as hand held computers have become valuable tools by providing locationg independent data processing capabilities for mobile workers. Nichols and Myers [4], for example, consider mobile phones to be *preferred mode of interaction with many appliances*. Their paper introduces a personal universal controller, which was designed for controlling different types of devices using a special control protocol. Other systems that utilized mobile terminals as remote control terminals are, for example, [3] and [5].

Our study aimed at finding a working solution for an industrial process monitor to achieve true location and terminal independence. As opposite to Nichols' and Myers' work, we do not try to provide a universal control language, because each industrial system requires their own special features, but our motivation is to provide a remote access and a user interface to wireless terminals. Bringing process control to mobile devices and heterogenous networks has several advantages, for example:

- Less traveling for key persons.
- Quicker response times, because of the location independence.

Even though mobile computing devices have become powerful application platforms, which are used in almost all fields of the modern society, and they have all the capabilities required for monitoring and controlling processes, there are still several obstacles on the way. Data security for example; such a device in the wrong hands could be used for

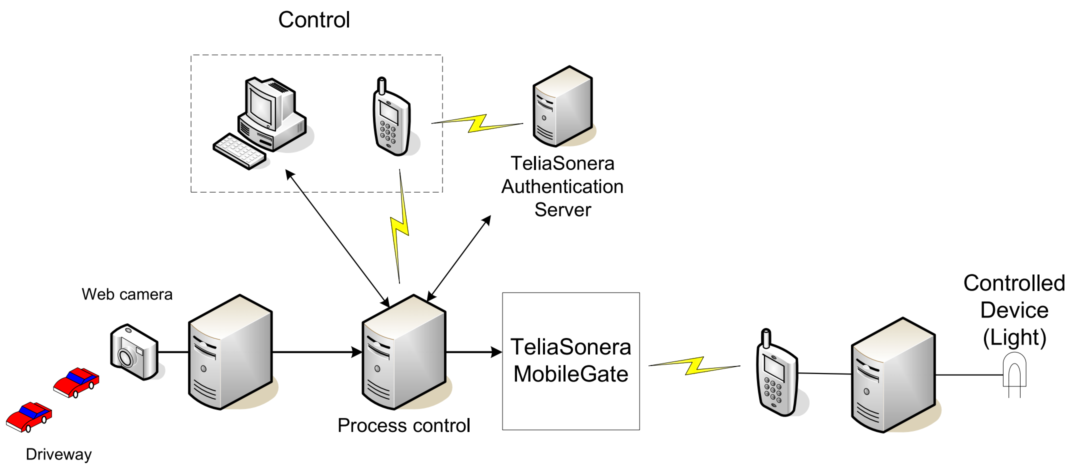

Figure 2. Prototype sytem setup.

industrial espionage, or even to sabotage the process with dire consequences. Also the user interface design needs to be thought out, because of the constraints imposed by the small screen and keyboard of the device. On the other hand, we do not want to limit the system to be controlled only by mobile terminals. Our goal is to create a system, which enables mobility support for control systems, bul also makes it possible to take advatage of greater resources of desktop computers. Such an approach requires terminal independent content provision system, which are discussed, among others in [1] and [2].

2 Controlling mobile services

This paper presents a system and a prototype to test the suitability of current technology to the above mentioned environment. A prototype was designed as a proof-of-concept for the fact that it is indeed possible to implement process control systems that involve heterogenous networks and devices. In addition to the device system, a content and device classification service was also devised, which was used in the prototype to automatically tailor the user interface to be suitable for devices from workstations to mobile phones. This kind of an approach is invaluable in environments where a number of different types of terminals exist. It is not practical to create fixed user interfaces for different device types, instead a dynamic content generator should be used.

An initial problem for the mobile devices to be controllable is that the control system has to be able to connect to them. It's not enough to get access from a cell phone to a server, we also need to connect to the mobile device. Ordinary devices using GPRS or 3G connections cannot be connected to, mainly because they do not have a public IP address or the cellular operator is blocking all incoming connections. In our test case, we used a special Mobile Gateservice [1] provided by TeliaSonera. The service is aimed at industrial markets, and it allows mobile devices to accept TCP connections from other authorized devices, thus enabling the mobile end to act as a controllable server. Eventhough the Mobile Gate enables the incoming commections to the mobile end, the mobile terminal must open the data channel to the base station. After the base station has provided the mobile terminal a communication channel, a remote system is able to communicate with it.

We have developed a prototype process control system called DynaControl that utilizes mobile devices and wireless networks to bring mobility and flexibility into process control. Figure 2 presents the prototype system setup. In the prototype, a light is changing its color from green to yellow to red depending on the amount of traffic that a web camera is recording on a highway.

The prototype system has all the parts of a real process control system. The system receives sensor data from a web camera aimed at a highway. Using machine vision technologies, the amount of traffic on the road is calculated and fed into the process control system. In our system a Linux server is used for controlling the system and presenting users with a monitoring and managing user interface. The server software was developed in the Python programming language.

3 Content adaptation

Authenticated persons can monitor the amount of the traffic and tune the algorithm controlling the light using a wide range of fixed and mobile devices. The type of a device connecting to the user interface is determined using the

[1] The Mobile Gate is a physical layer VPN solution which uses a private APN and a closed core network of TeliaSonera

Table 1. Some content classification rules

Media type	Terminals	Alternative presentation(s)	Rule set
Picture	Computer	Text	Show the picture
	Mobile phone	Scaled picture Hyperlink to the picture Text	Show a scaled picture or a hyperlink and the text
Audio	Computer	Text	Repeat audio as it is
	Mobile phone	Hyperlink to the audio file Possibility to save the audio file	Show a hyperlink to the audio file
Buttons	Computer	Hyperlink	Show the element as it is
	Mobile phone	Hyperlink	Reduce element size and show or Show a hyperlink

WURFL [2] device description library. After the device type has been determined, the user interface is tailored to suit the specific device using a set of content classification rules. In addition to the terminal determination the speed of the connection was also estimated using terminal response times. In Table 1 there are some examples of the rules in use.

When using the DynaControl system with a computer, the user sees a full user interface with a video stream from the web camera and graphs representing history data. Controlling the system is done with slider components on the web page. A mobile user with a handheld computer only gets smaller graphs and a possibility to control the system by typing in new values. When using the system with a cell phone, the user does not see any graphs, just numerical data about the current and historical conditions.

4 Security

Finally, a system used in a process control environment needs the ability to authenticate its users reliably due to the risks involved. The proposed system fulfills this requirement by employing a two-factor authentication method, where the authentication requires that the user knows something (username, password and a PIN code) and that the user has something (the SIM card). For the authentication process a special mobile phone SIM-card is used in addition to a username and a password. When a user wants to enter the system, he inputs a username and a password. Then the process control server sends a request to the Mobile Gate authentication server, which acts as a trusted third party, requesting the user to be authenticated. The authentication server sends a challenge to the users's mobile phone, where a special SIM-card cryptographically crafts a response. After verifying the response, the authentication server sends a message to the process control server to accept the client.

[2] http://wurfl.sourceforge.net/

5 Results

The results of our study is twofold: First, we created a system that has an ability to tailor the user interface to fit the properties of any device the user is using the system with. The only restriction is that the access terminal has to be recognized by the WURLF device database. The process control server automatically determinates the qualities of the connecting device using header information from the HTTP request. With the qualities of the device known, the content classification rules are used to convert the user interface components to suit the devices capabilities. Time series, for example, are displayed as graphs on workstations and as numeric data on small mobile phones. This gives us the flexibility we were searching.

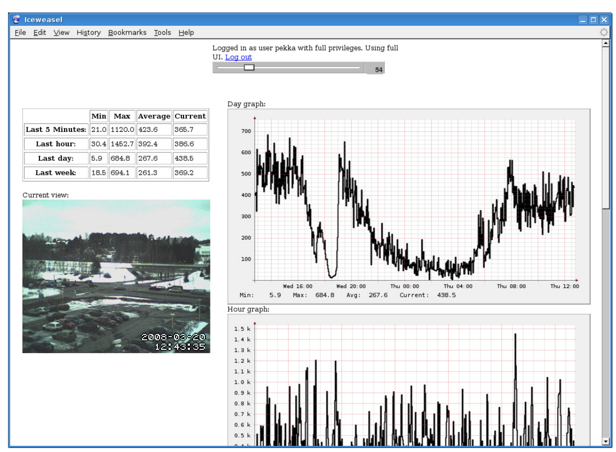

Figure 3. Screenshot from the prototype monitoring and controlling user interface.

Second, we were able to set up a remote controllable system, in which both ends are connected via cellular network. This provides us with a location indepencende for both of the ends. A unique feature of our system is that the controlled system is not required to maintain a TCP connection to the process control system, but the process control system can also initiate connections to the static IP address held by the controlled systems cellular modem.

6 Conclusion and Future Work

We have shown that it is possible to build a system, where heterogenous devices are communicating over secure cellular links to form a process control system. Currently the normal GPRS/3G cellular systems do not provide bidirectional access, but with a special operator service this is possible. In the near future when new access technologies emerge, this will most probably be a standart feature.

The rules for creating ”the best possible” UI for different devices also fulfills the requiremets for normal HTML components. In the next step, we will study the reliability and QoS of the cellular connection to be able to set limits for the control traffic.

References

[1] M. Butler, F. Giannetti, R. Gimson, and T. Wiley. Device independence and the web. *Internet Computing, IEEE*, 6(5):81–86, Sep/Oct 2002.

[2] T. Glover and J. Davies. Integrating device independence and user profiles on the web. *BT Technology Journal*, 23(3):239–24, Jul 2005.

[3] Y. Imai, Y. Hori, and S. Masuda. A mobile phone-enhanced remote surveillance system with electric power appliance control and network camera homing. In *Proceedings of the Third International Conference on Autonomic and Autonomous Systems, ICAS07*, pages 51–56, 2007.

[4] J. Nichols and B. Myers. Controlling home and office appliances with smart phones. *IEEE Pervasive Computing*, 5(3):60–67, 2006.

[5] K. Tan and C. Soh. Internet home control system using bluetooth over wap. *Engineering Science and Education Journal*, 11(4):126–132, 2002.