GINSENG for Sustainable Energy Awareness*

Flexible Energy Monitoring using Wireless Sensor Nodes

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ABSTRACT

To ensure sustainable manufacturing the energy consumption of production processes must be minimized. SAP Research is active in two European Community's Seventh Framework Program (FP7) projects: GINSENG and KAP. The combined aim of GINSENG and KAP projects is to allow for event-based monitoring of the Production Performance Indicators (PPI) that can be used to, e.g., shut down idle machines or to optimize the material flow.

In this demo we illustrate how the energy consumption for lightening and heating can be controlled with the use of wireless sensor nodes that measure temperature, light and humidity. Events describing the indoor climate, originating from TelosB motes, are processed using the middleware developed within the GINSENG project and subsequently visualized using a dashboard. Visualization includes also warnings regarding excessive energy consumption, which can be simulated with light beams or hand warmth.

Keywords

Energy Awareness, Real-Time Monitoring, Middleware, Event Processing

1. INTRODUCTION AND BACKGROUND

For many areas, such as manufacturing plant automation, predictive maintenance, and monitoring of employees in hazardous environments performance assurances like timeliness, accuracy and reliability are crucial. Therefore, the GINSENG Project [5] focuses on the development of a performance controlled wireless sensor network, which will be used for monitoring of the GALP refinery in Sines, Portugal.

Goals of the GINSENG project go beyond the development of an energy efficient wireless sensor network. An important aspect of the GINSENG project is a middleware layer which connects the field devices with ERP systems. Existing middleware solutions, such as [4, 6], unlike the GINSENG middleware, support only basic pre-processing of events. Specifically, they do not provide any quality and/or performance control mechanisms required by the industrial applications.

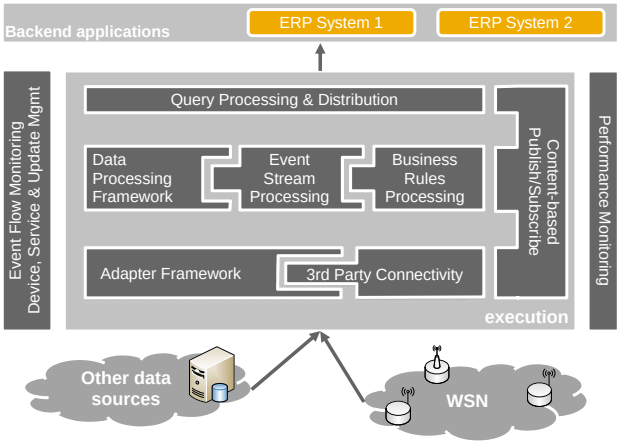

Figure 1: GINSENG middleware overview

The GINSENG middleware (see Figure 1) addresses this issue by providing performance monitoring and control including, among others, reliability, timeliness and precision. Moreover, the GINSENG middleware provides: (i) an *Adapter Framework* as the abstraction to conceal the heterogeneity of underlying sensor nodes; (ii) a *Data Processing Framework* to combine the stateless content-based publish/subscribe system with traditional event stream [3] and complex business rules [2] processing engines; (iii) a *Query Processing & Distribution* component to enable an automatic, user-transparent management and distribution of incoming queries over all plugged-in engines; and (iv) a robust monitoring and management of application logic and event flow.

The KAP project envisions a sustainable manufacturing environment powered by the ICT. The goal of the KAP project is to develop optimization strategies to minimize the energy consumption of production processes. To this end, KAP builds on top of the GINSENG architecture and enables a real-time monitoring and processing of harmonized and standardized PPIs. KAP goals include also visualization of the energy consumption and derivation of energy saving activities. Therefore, the KAP project address both

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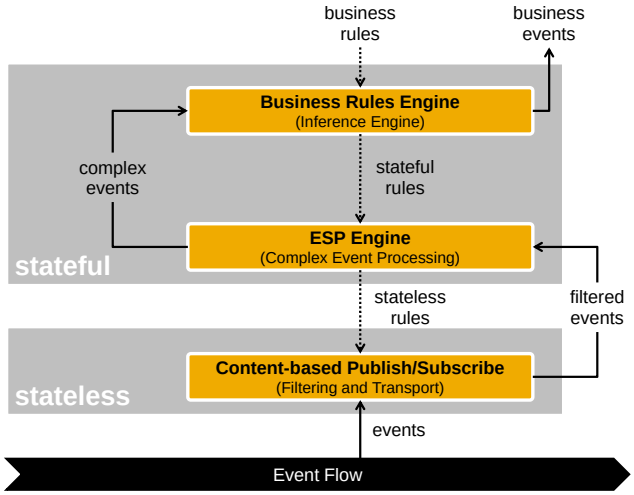

Figure 2: GINSENG Data Processing Framework

manufacturing experts (methods to „green-up" production processes) and consumers (visualization of the energy costs required to produce certain goods). As a result KAP covers the whole end-to-end energy life cycle of products starting from production and ending with daily use.

2. SYSTEM ARCHITECTURE

PPIs in KAP project include indicators like produced items per minute, process idle times, scrap rate, power consumption per machine and energy consumption peaks. In this interactive demo, we reduce the KAP scenario to the omnipresent energy consumption indicators. Our energy consumption indicators include: (i) light, (ii) heat, and (iii) humidity which are used to monitor the room climate. This seemingly basic scenario is an important factor in manufacturing environments, especially in the high-tech, chemical or pharmaceutical industry.

Our demonstration system consists of three main components. First, wireless sensor nodes (TelosB motes running the Gin(seng)MAC protocol) that record temperature, light, and humidity are used to monitor the room-climate. Energy waste due to, e.g., over-heating or inappropriate lighting can be simulated using a heat source or using additional light sources. On top of that we deploy the GINSENG middleware which collects events produced by the wireless sensors. Collected events are subsequently processed by the GINSENG Data Processing Framework (see Figure 2) and delivered to the visualization application.

The combination of GINSENG WSN protocol (GinMAC) and GINSENG Data Processing Framework provides a performance controlled infrastructure for the real-time WSN event processing. The GINSENG Data Processing Framework (DPF) consists of two main parts – the stateless part which filters incoming events and the statefull part which is an interface for the business rules. Within the DPF we use the principle of upstream evaluation and downstream replication in that we stateless parts of the business rules directly into the publish/subscribe system. The publish/subscribe system decouples [1] the middleware components from each other and transports the stateless parts of business rules into

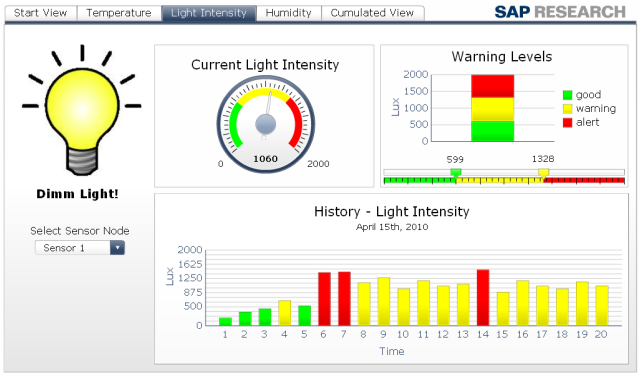

Figure 3: Energy consumption monitoring

the proximity of the data sources allowing to filter the irrelevant events before they propagate throughout the GINSENG middleware. The GINSENG DPF closes the gap between the devices (sensors) at the manufacturing shop floor level and the business management and ERP systems.

Finally, the processed events containing sensor data are visualized using a dashboard – see Figure 3.

3. CONCLUSIONS

This demo paper has two goals. First, we present the GINSENG middleware that enables (i) performance-controlled device integration and (ii) combination of wireless sensor event stream processing and business rule evaluation using a three-tier GINSENG Data Processing Framework composed of a stateless publish/subscribe system, traditional event stream processing system and business rule processing engine. Second, we show how GINSENG middleware can be applied beyond the scope of the original GINSENG project. In this demo paper GINSENG middleware supports the monitoring of the energy-related PPIs. The result of the PPI monitoring is the energy-aware management of the indoor climate and, in future, the control of sustainable manufacturing processes.

4. REFERENCES

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