Towards the Improvement of Monitoring and Control Agencies through Knowledge-Based Approaches

Matteo Palmonari, Fabio Sartori

Department of Computer Science, Systems and Communication
University of Milan-Bicocca
What is Pervasive Computing?

The pervasive computing paradigm, or ubiquitous computing as others prefer to call it, is concerned with a new way of conceiving the interaction among humans (users) and computing devices.
Towards the Improvement of Monitoring/Control Agencies through Knowledge-Based Approaches

Pervasive Computing Systems Classification

Lyon classifies PC issues on the basis of data nature

- **Personal Data**
- **Spatial Location Data**
- **Biometric Data**

PDAs, Smart Cards...

Intelligent Buildings, Infrastructures, GPRS...

Processing of Medical Data, Digital Identity, Under-skin Chips...
Towards the Improvement of Monitoring/Control Agencies through Knowledge-Based Approaches

Monitoring and Control Systems

Spatial Location Data

- Sensors collect data;
- Data are transmitted to humans...
- ... Or used by system to perform control tasks ...
- ... Or to support human operators in their daily activities
Towards the Improvement of Monitoring/Control Agencies through Knowledge-Based Approaches

An Architecture for Monitoring/Control Systems

A minimal set of requirements should be guaranteed:

• clearness of the underlying policy of control
• soundness according to the policy
• flexibility, in order to be adaptable according to both different specific contexts and future changes in the policy
• modularity

We propose a four-level architecture for monitoring/control systems, extending the traditional three-level architecture.
Towards the Improvement of Monitoring/Control Agencies through Knowledge-Based Approaches

Four Levels Vs. Three Levels

Three Levels
- Observation Level
- Interpretation Level
- Actuation Level

Four Levels
- Correlation Level
- Correlation Agency

WOA 2003 - Villasimius, September 11th
Further Details

- **Observation Level**: sensors perform data acquisition;
- **Interpretation**: data acquired are interpreted according to system goals;
- **Correlation**: local interpretations are correlated in order to generate a more precise and complete view of a situation;
- **Actuation**: actions are taken in order to solve possible problems, according to the output of the Correlation step;

The agent-based model seems to be the most suitable approach to develop this architecture.

Every level is governed by a specific *agency*.
Towards the Improvement of Monitoring/Control Agencies through Knowledge-Based Approaches

Why an agent based framework for Monitoring/Control systems

MCS _______ widely distributed environments

- different devices (some of them embedded in the environment)
- autonomous
- separated concerns
- communicating

cooperation towards the system’s goal

In such distributed environments, where distributed tasks are performed by autonomous entities, the agent based approach provides a useful and powerful framework to work within (N.R. Jennings. On agent-based software engineering. 117:277–296, 2000).

WOA 2003 - Villasimius, September 11th
Agency vs. Agent

Agent $\rightarrow$ different definitions (Wooldridge, Jennings, Genesereth, ...)

Agency $\rightarrow$ a functional point of view:

• Identifies a set of functions typical of an agent (that respond to a given definition of agent)

• Need not to be an agent itself, but can be implemented by:
  • one or more agents. (Each one can have the same features of the agency or these features can be the product of their combined action)
  • different modules that are not agent themeselves but whose combined action return the agency features (agent-like)
Towards the Improvement of Monitoring/Control Agencies through Knowledge-Based Approaches

A Four Level Agent-Based Architecture

- Reactive Agents
- Observation Level
- Interpretation Level
- Actuation Level
- Utility-Driven Agents
- Correlation Agency

WOA 2003 - Villasimius, September 11th
SAMOT supports traffic operators devoted to traffic monitoring and control providing them with
– a set of *data about traffic situation*
– *acoustic and visual warnings* when anomalous traffic conditions are detected
– *tools to directly undertake the needed operations* on SAMOT devices when traffic anomalies are detected
  • selection, creation and activation of an adequate sequence of camera images to be shown on the CCTV (to verify the detected anomaly)
  • activation of messages on VMP (to inform motorists)
Towards the Improvement of Monitoring/Control Agencies through Knowledge-Based Approaches

The Architecture of SAMOT

- Video-Cameras
- Car Drivers
  - Observation Level
- VIPs
  - Interpretation Level
- MCA
  - Correlation Level
- Traffic Operators
  - Actuation Level
- Lightening Panels
Towards the Improvement of Monitoring/Control Agencies through Knowledge-Based Approaches

Correlation Agency in SAMOT: the MCA

Actions are taken according Anomalous Traffic Patterns by MCA itself or human operators

Anomalous Traffic Patterns: MCA correlates AA to create a global view of traffic conditions

Atomic Anomalies
Towards the Improvement of Monitoring/Control Agencies through Knowledge-Based Approaches

MCA Policy

```matlab
if
    (Initial state = RegularTraffic(k))
    % portion k is characterized by ‘Regular Traffic’
    (Anomaly = VStopped(k), ts)
    % ‘Stopped Vehicle’ detected on k at time ts
then
    (ActionsGUI = VStopped(k))
    % ‘Stopped Vehicle’ anomaly shown on operator GUI
    (Beep = ‘yes’)
    % acoustic warning to operators
    (Video = ‘k’)
    % images on CCTV are fixed on the portion k
    (Panels(k) = ‘Incident’)
    % adequate message for VMPs are created
    (Time = ts)
    % immediate operator alerting
    (Duration = ‘Event’)
    % control actions end when the anomaly ends
```
Concluding Remarks

• The correlation agency is the element that improves robustness, reliability and reasonability of a monitoring/control system, since it exploits the core knowledge of domain experts.

• The addition of MCA to the architecture of the system has allowed to avoid interpretation errors by VIPs, that were quite frequent

• Future works consist in the application of the architecture described to a new research project, called TESTIS, in which other important aspects of pervasive computing (like, for example, privacy) will be considered.
Towards the Improvement of Monitoring/Control Agencies through Knowledge-Based Approaches

Thank you