



# Context-Aware Medical Content Adaptation through Semantic Representation and Rules Evaluation

**Charalampos Doukas<sup>1</sup>, Ilias Maglogiannis<sup>1,2</sup>,  
Kostas Karpouzis<sup>3</sup>**

*<sup>1</sup>University of the Aegean Dept. Of Information & Communication  
Systems Engineering, Greece*

*<sup>2</sup>University of Central Greece, Department of Biomedical Informatics  
Lamia, Greece*

*<sup>3</sup>Image, Video and Multimedia Systems Lab, National Technical  
University of Athens, Greece*

# Overview

- Introduction
- Enabling Context Awareness
  - Patient Status Awareness
  - User Environment Context Awareness
- Context Semantic Representation
- Content Adaptation
- Semantic Rules Evaluation
- Proposed System Architecture
- Conclusions - Discussion

# Introduction

- Numerous telemedicine applications in literature
  - Remote medical action
  - Remote medical care
  - Medical data/knowledge exchange
- Optimization of patient treatment – diagnosis – care procedures
- Collaborative applications
  - Educational purposes
  - Assessment assistance



# Introduction

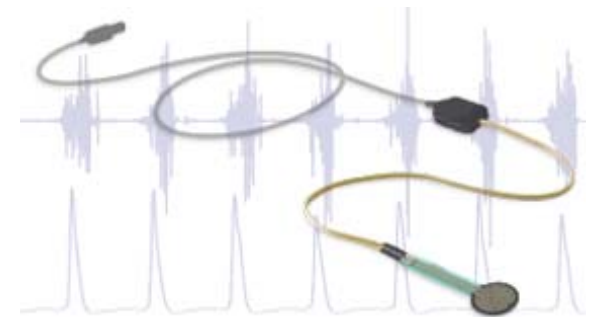
- Issues:
  - Remote Locations – Networking infrastructures (wired & wireless)
  - Transmission of large volume data (e.g., medical images)
  - Unnecessary transmission of data (e.g., normal patient status)
  - Quality of Service of wireless networks
- Solutions:
  - Proper content coding (data compression)
  - Context-aware medical networks

# Introduction

- Our Proposal:
  - A context aware medical content adaptation platform
  - Semantic representation of content and context
  - Proper reasoning techniques -> content adaptation
    - Transmission only when determined necessary
    - Proper data encoding
    - Based on network quality, availability, patient status
  - Open framework infrastructure

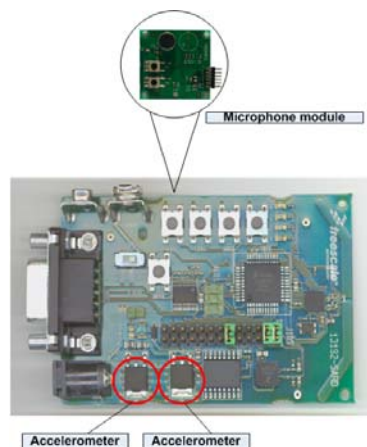
# Enabling Context Awareness

- Context awareness refers to the ability of systems to react based on their environment
- In the domain of patient remote care context awareness refers to detection of patient status and appropriate adaptation of the medical services according to the latter status and environmental conditions
- Patient Status Awareness
- User Environment Context Awareness



# Enabling Context Awareness

- Patient Status Awareness:
- Continuously monitoring the patient state
  - Biosignals: heart rate, blood pressure, temperature,...
  - Information than can indicate emergency status: patient fall, call for help, etc..
- Equipment installed on patient's body (Body Sensors Networks)
- Equipment installed on user's surrounding area (Cameras, ...)
- Sensor example



On-body sensor node for collection sound and movement data from the user. It can be utilized for detecting fall events and other distress situations

# Enabling Context Awareness

- Patient Status Awareness:
- Data Processing & Classification:
  - Proper filtering (e.g., noise removal)
  - Apply thresholds in simple cases (e.g., body temperature or heart rate)
  - Apply advanced classification techniques (e.g. patient movement or sound data)
    - Support Vector Machines
    - Neural Networks
    - Gaussian Mixture Models
    - ...

# Enabling Context Awareness

- User Environment Context Awareness:
- User location (indoor, outdoor)
  - Facilitate ambulatory process dispatching
  - Proper proactive or reactive data transmission
- Underlying network infrastructure
  - Transmission capabilities (wired vs wireless)
  - Real time conditions
- Communication equipment
  - Laptop – PDA – mobile device - ...

# Context Semantic Representation

- Both the patient-related context and content have been modeled
- Medical Content:
  - Image-Video medical data
  - Medical Audio
  - Biosignals
- Patient Status:
  - Distress state (physiologically)
  - Movement state (falls, inactivity, etc.)

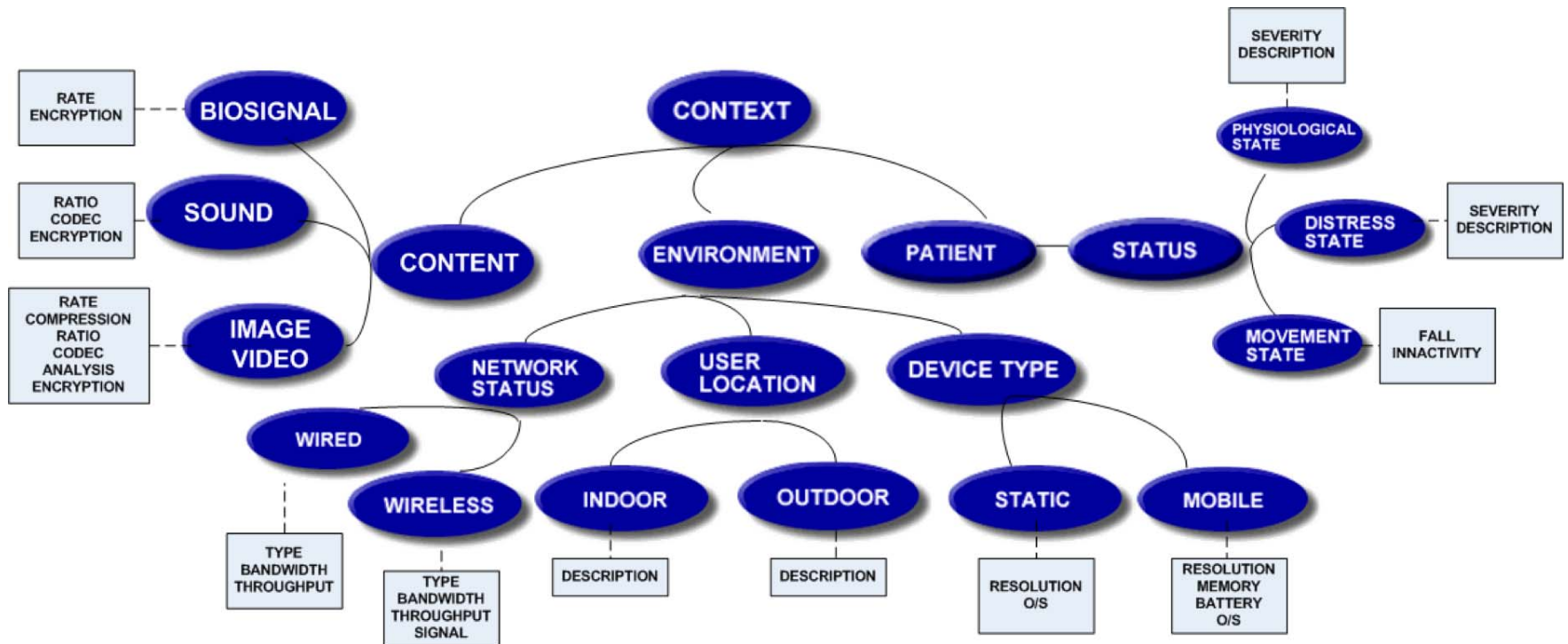
# Context Semantic Representation

- Patient Environment:
  - Network Status
  - Patient Location
  - Device type
- Appropriate features have been defined for each class
- Ontological model created using Protégé and OWL

# Context Semantic Representation

- Benefits:
  - Flexibility to modify and extend the contextual scheme by adding more classes
  - Better and more flexible evaluation of the context facilitating the decisions for the medical content adaptation
  - Semantic rules can be updated and extended without any need for system platform software modifications

# Context Semantic Representation



# Content Adaptation

- Content adaptation refers to proper medical data coding and proactive or reactive transmission
- Better utilization of network and system resources during the monitoring and treatment process
  - Image and Audio/Video proper coding, e.g.,
    - Uncompressed data in fast wired networks
    - Higher compression in wireless networks
    - Region of Interest (ROI) coding for maintaining visual assessment
  - Adapted Data Encryption, e.g.,
    - According to the sensitivity of the data and the severity of the case -> simple symmetrical encryption schemes to public key infrastructures

# Content Adaptation

- Reactive Data Transmission
  - In case of normal patient state, data related to the patient context and status (e.g., visual data and biosignals) can be transmitted to monitoring units proactively in specified time intervals
  - In case of a detected distress situation, reactive transmission can begin

# Content Adaptation based on Semantic Rules Evaluation

- Decision on content adaptation: Semantic Rules
- These rules concern features of the ontological class that represents the context aware model semantically
- By performing proper evaluation of the latter, decision regarding the content adaptation can be made
- Semantic Web Rule Language (SWRL) has been utilized for the creation of the Rules
  - Within Protégé environment
  - Using Jess rule engine (Jess provides both an interactive command line interface and a Java-based API to its rule engine)

# Content Adaptation based on Semantic Rules Evaluation

- Examples of SWRL Rules:

```
Patient(?x) ^ PhysiologicalState(?y) ^  
hasSeverity(?x,?y, ?severity) ^  
hasDescription(?y,?description) ^  
Biosignal(?BS) ^ BiosignalRate(?Rate) ^  
swrlb:otherThan(?severity,?Normal) ->  
DefineTransmissionRate(?Rate,"100kbps")  
^ StartTransmission("true")
```

- Examines the physiological state of the patient as characterized by the status awareness modules in terms of status severity. If the latter is considered to be other than “Normal” then transmission of the collected biosignals to the monitoring units begins at a specific data rate.

# Content Adaptation based on Semantic Rules Evaluation

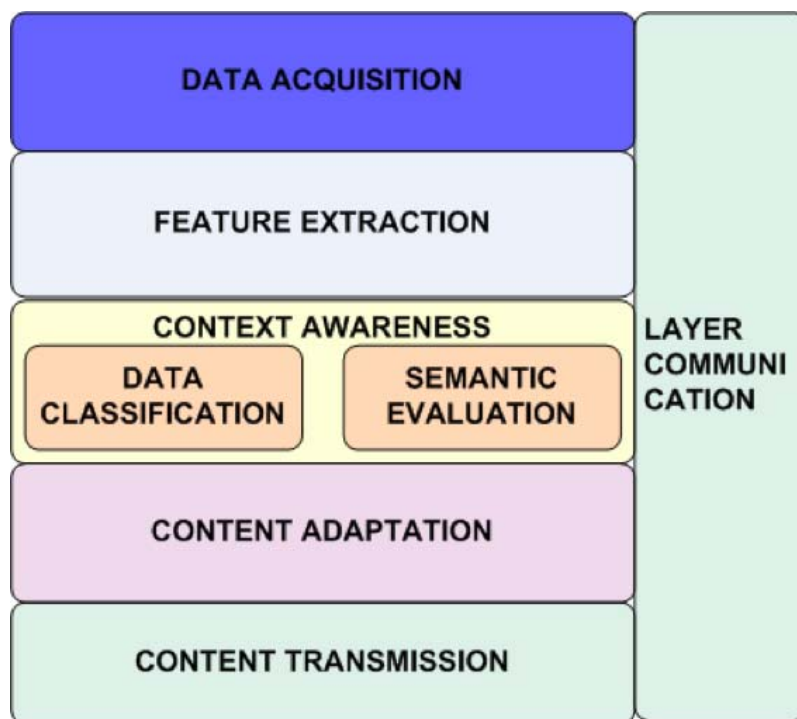
- Examples of SWRL Rules:

```
Patient(?x) ^ MovementState(?move) ^  
FallDetected(?x,?move) ^  
hasDescription(?move,?description) ^  
UserLocation(?Location) ^  
VideoRate(?Rate) ^ NetworkStatus(?Wired) ^  
swrlb:equals(?move,"Fall") ^ swrlb:equals  
(?Location,  
"Indoor") ^ swrlb:equals(?Wired, "true")  
->  
DefineVideoRate(?Rate,"300kbps") ^  
StartTransmission("true")
```

- Takes into consideration potential indication of a fall event, the location of the user and the network status. According to the rule, video transmission of the patient's premises will begin in case a fall has been detected. High transmission rate will be used if the user is located indoor and a wired network infrastructure is used

# Proposed Architecture Scheme

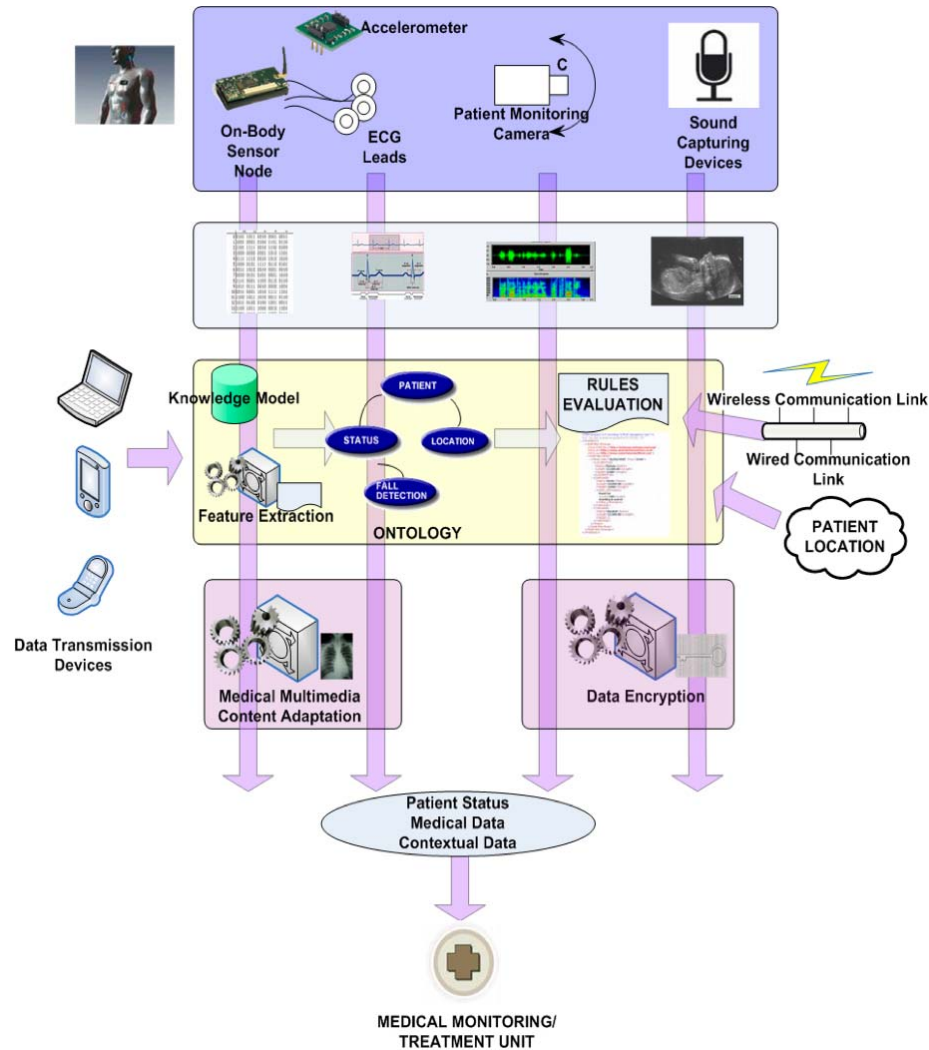
- The interconnection and communication of the different components can be illustrated as five different application layers



# Proposed Architecture Scheme

- 6 basic modules:
  - Sensor – Devices collecting patient-related data
  - Data Feature Extraction and Classification Data Module
  - Ontology Module
  - Rules Evaluation Module
  - Medical Multimedia Content Adaptation Module
  - Data Encryption Module

# Proposed Architecture Scheme



# Conclusions

- A context-aware medical content adaptation platform has been presented
- A semantic representation for the patient context has been developed and appropriate rule-based system is used in order to perform proper medical content adaptation according to the context, facilitating and improving the diagnosis and treatment process
- Future Work: deployment of the proposed platform in a real remote treatment and monitoring environment
- *Acknowledgement:* This work has been partly funded by the EU via the CALLAS Integrated Project (contract number 034800, [www.callas-newmedia.eu](http://www.callas-newmedia.eu))