Telecare Service Challenge: Conflict Detection

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context: Personalised Ambient Monitoring

Is it possible to obtain, in an automatic, ambient and unobtrusive manner, 'activity signatures' from the mentally ill that provide information about the trajectory of their health status?

- The University of Stirling
  - Networking services and middleware
- The University of Southampton
  - Operational Research (OR)
  - Biomedical signal and pattern processing
- The University of Nottingham
  - Novel instrumentation for physiological monitoring

EPSRC
Engineering and Physical Sciences Research Council

PAM
Personalised Ambient Monitoring

http://www.pam-research.org

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context: sensors

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3

context: Ambulatory Assessment

- monitor patients on the move, in their home and work settings
- Assessment in real-time, avoiding recollection or reconstruction bias
- Real-life-based assessment
- Continuous assessment
- Multimodal assessment
- Interactive assessment

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4

context

- personalisation
  - variation between individuals
  - variation over time for particular individuals
- telecare systems can be programmed in real time
  - rule based
  - changing for individuals over time

Context: State of the Art

- PAM
  - Collected data from mobile and home environments
  - Limitations
    - Static data collection for offline processing
- MyExperience
  - Mobile phone based sensing and self-report system
  - Automatic recording of data to mobile DB on phone which synchronised with web server
  - Sensor -> trigger -> action rules expressed in XML
  - Limitations
    - Not integrated with home monitoring sensors
    - event chaining not supported
    - Potentially prone to conflicts

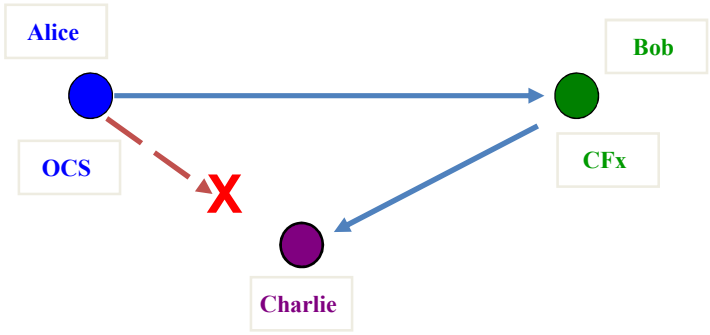
Context: State of the Art

- Tacconi et al.
  - use of depression and mania scales
  - proposed a system architecture
  - Limitations
    - work may be dormant
- Alarm Net
  - It combined environmental and physiological readings, provided real-time data analysis
  - modified the network on the fly
  - Limitations
    - Can not obtain data outside the residential facility.
    - did not incorporate qualitative data from the subjects.
    - attempt was made to reduce conflicting commands

motivation

- when rules are:
  - changing over time
  - possibly unique for particular individuals
  - originating from different stakeholders
- how can we ensure the integrity of the rules
  - in particular the lack of conflicts between rules

motivation: feature interaction



- Alice cannot call Charlie
  - Originating Call Screening (OCS)
- If Alice calls Bob
  - Bob's Call Forwarding transfers call to Charlie

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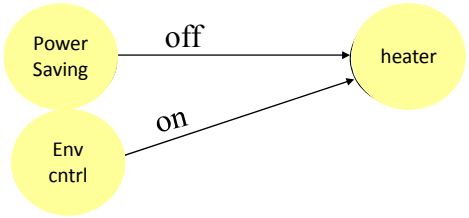
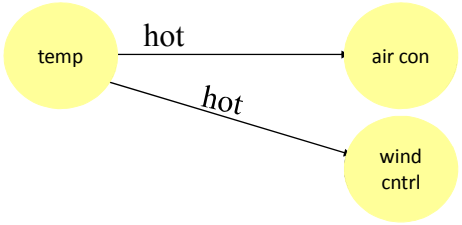
classes of feature interactions

1. **MAI**: Two (or more) features control the same device (Multiple Action Interaction)



2. **STI**: One event goes to different services which perform different conflicting actions (Shared Trigger Interaction)



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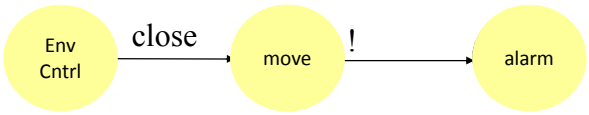
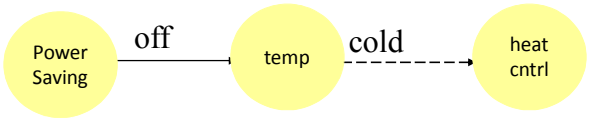
classes of service interactions

3. **SAI**: A service performs an action on a device which triggers another feature. The chain might involve any number of links (Sequential Action Interaction, Loops)



4. **MTI**: The existence of one feature prevents the another one from operating. (Missed Trigger Interaction)



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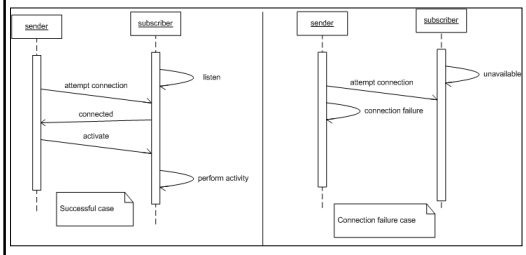
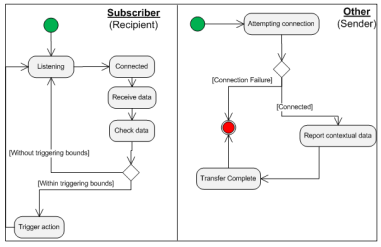
11

Feature Rules

Service Group	Service	Feature
Device Control Services		
	Device Management	
		Activate Immediate (AI)
Knowledge Services		
	Context Detection Service	
		Context Triggering (CTS)



Activate Immediate Sequence Model



Context Triggering System Activity Model

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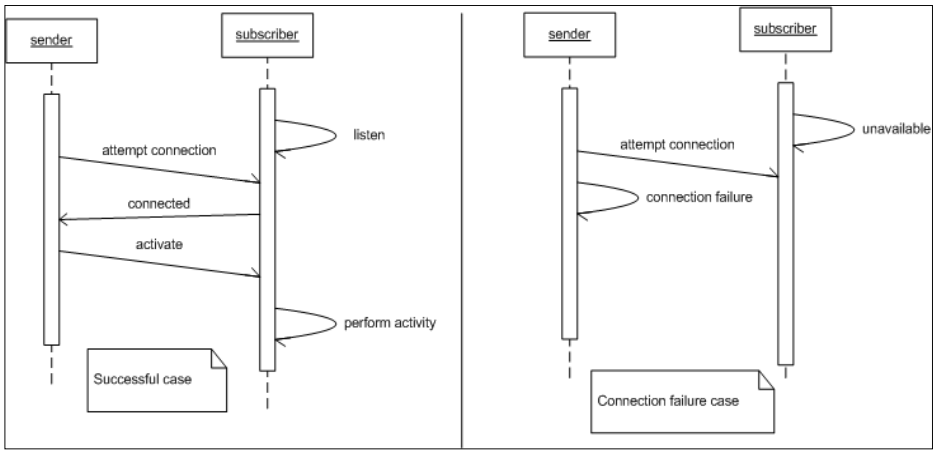
12

Activate Immediate Sequence Model



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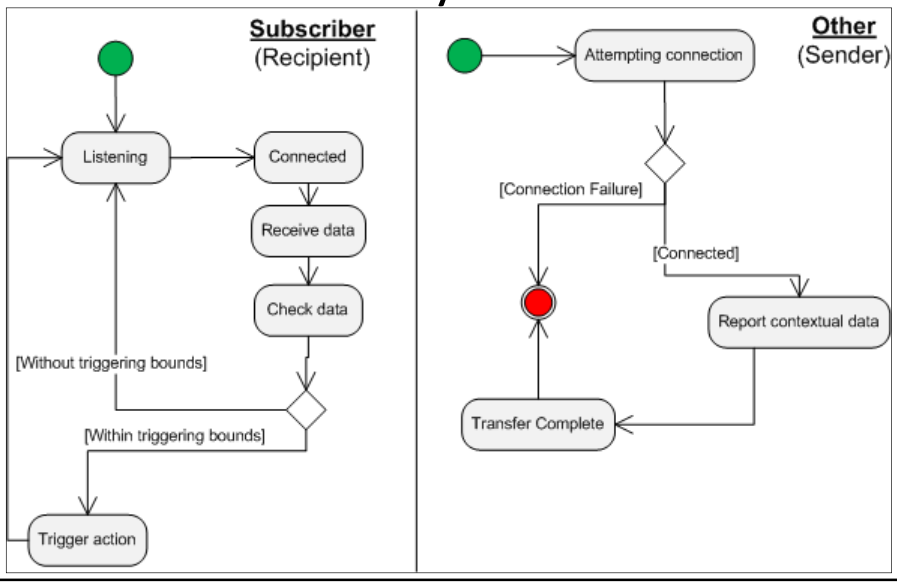
13

Context Triggering System Activity Model



Event Calculus Rule Description

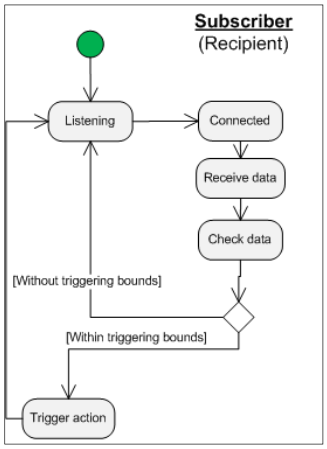
- The activity models can be translated into EC logic language
- The Event Calculus
  - Represent and reason about actions and their effects in time
  - Main concepts: fluents, actions (or events) and time points
  - Defined using the Horn clause subset of first-order predicate logic

Event Calculus Rule Description

- fluents
  - global properties that can change in time
  - can hold at a particular time if initiated by action and has not been terminated
  - propositional: subject in house
  - quantifiable: level of ambient noise
- actions
  - occur at points of time
  - can modify fluents
- time points
  - discrete time

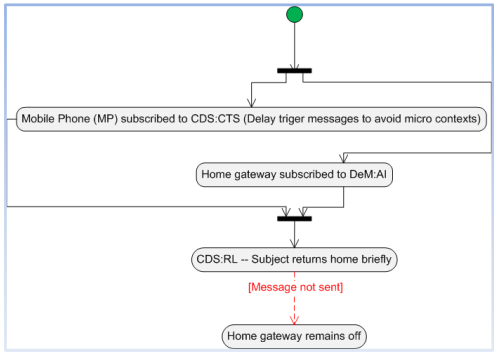
example: Context Triggering System

```
1 % respond to changes upon receiving contextual information
2 cds_cts(Trigger,T) :-
3 T2 is T+1,
4 assert(happens(listen_for_connection,T)),
5 assert(happens(make_connection,T)),
6 assert(happens(receive_data,T)),
7 assert(happens(checks_data,T)),
8 assert(happens(listen_for_connection,T2)),
9 ((
10 holdsAt(message(Trigger), T2),
11 assert(initiates(checks_data,prompt(Trigger),T)),
12 assert(terminates(checks_data,message(Trigger),T))
13 );
14 assert(terminates(checks_data,message(Trigger),T))).
```



Conflict Analysis

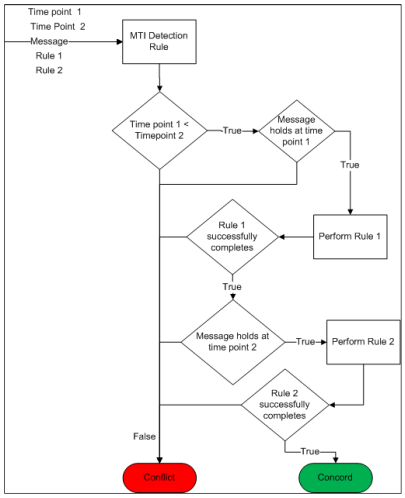
- Offline and online analysis looking for conflicts between device rules
- Like FI for call control
- Searching for 5 types of conflict:
  - STI, SAI, LI, MAI, MTI
- 12 case studies were developed to explore the conflicts



Missed Trigger Interaction occurs when the Context Triggering rules delay the activation of a home gateway.

Detection Approach

- Prolog-based framework
- Evaluates pairs of feature rules to determine whether they are concordant or conflict



Example diagram describing MTI conflict detection rule

Device Priority Approach to Resolution

- Allows precedence across devices without their knowledge of each other
- How it works
  1. Resolver receives a list of conflicts, device priorities and device rules
     - Priorities are declared as ordered preference lists of particular properties (such as power efficiency, bandwidth minimisation, data integrity, etc)
     - Rules may be listed for each property
  2. Resolver determines rules that should be disabled

Analysis Results

MTI Case Study		
Notification suppression	Notification suppression	MTI
Notification suppression	Response prompting	MTI
Response prompting	Notification suppression	MTI
Response prompting	Response prompting	MTI

SAI Case Study		
Data Transfer	Data Transfer	SAI
Data Transfer	Data Redirect	SAI
Data Redirect	Data Transfer	SAI
Data Redirect	Data Redirect	Concordance

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future work

- 867 tests for combing a shared trigger, multiple action, SAI.
  - from 17 features against each other and themselves across the three criteria.

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Thank you

- Any questions?

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DEVICE NODES

- Worn
  - Mobile Phone
    - Questionnaire
    - Gateway Application
  - GPS Transceiver
  - Wearable Accelerometer
  - Wearable Microphone
  - Wearable Light Sensor
- Environmental
  - Microphone
  - Light Sensor
  - Passive Infrared Sensors
  - Micro-switches
  - Bed Sensor
  - Camera
  - Infrared Receiver For Remote Control
  - PC

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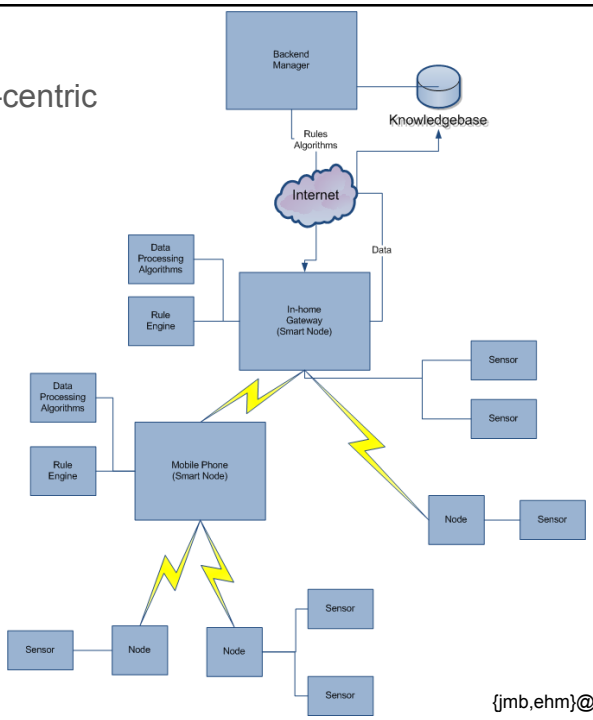
Mobile phone-centric sensor-based care system



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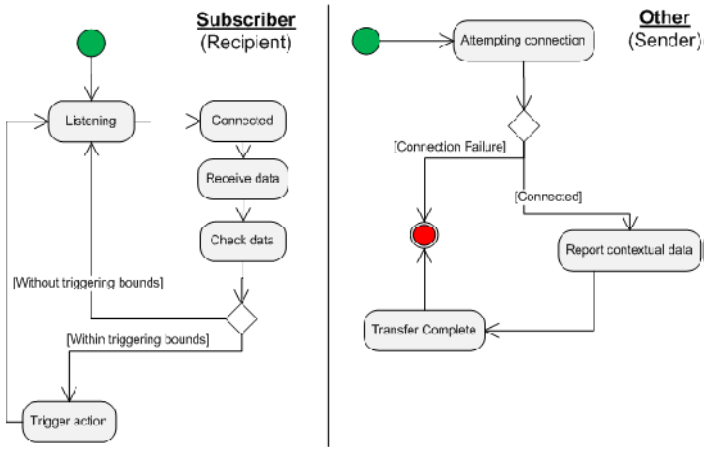
(a) Context Triggering System Activity Model



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(b) Context Triggering System Sequence Model
Figure 25: Context Triggering System Diagrams