MAGPIE: An Agent Platform for the Development of Mobile Applications for Pervasive Healthcare

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Different Components

- AGents
- Mobile computing
- Publish/subscribe
- Intelligent p-hEalthcare
p-Healthcare

• Architecture of Personal Health System (PHS)
Mobile Computing

• Well established market of smartphones and tablets
  ➢ HW with powerful computation capabilities
  ➢ New operating systems for handheld devices

• Android
  ➢ Open source solution
  ➢ Google play
Agents

- Autonomous, reactive, pro-activeness, social
- In PHSs shared environment with the patient
- Kinds of reasoning
  - Detection
  - Classification
  - Prediction

IntelligentAgent-SimpleReflex" by Utkarshraj Atmaram
Publish/subscribe

- Distributed event-based system
  - In PHSs events are alerts reported to the patient
  - Connecting patients with patients

P.T.H.Eugster et al., 2003
Putting it all together…

- State-of-the-art of PHSs
  - Tier-1: Patient + BAN
  - Tier-2: Mobile device acting as a gateway
  - Tier-3: Remote monitoring in a central server

- MAGPIE
  - Tier-1: Patient + BAN
  - Tier-2: Local monitoring with a mobile agent environment deployed in Android
  - Tier-3: Publish/subscribe architecture where relatives and doctors can subscribe to patient events in the mobile agent environment
Agent Platform (Tier 2)

- UML class diagram
  - Based on environment as first class abstraction (Weyns et al., 2007)
Deeper View

- Environment mediates the interactions between agents and context entities
  - Agents are interested on services
  - Context entities offer services
Active components’ lifecycle

- Environment
  - Initialization
  - Sleep
  - Notification
  - Agent Execution

- Agents
  - Initialization
  - Perceive
  - Is Model Change?
  - Update
  - New monitoring model loaded in the mind
  - Modify Model
Interactions for monitoring
Knowledge representation (I)

- Monitoring rules
  - Combination of events that in case of happening an alert must be triggered and notified
  - Two or more events in a time window where the order is not considered

- Events
  - Measurement of a physiological parameter that can be categorized as: high, normal, low
Knowledge representation (II)

• Based on the Event Calculus

(EC0) \texttt{holds\_at}(F=V,0) :- \texttt{initially}(F=V).

(EC1) \texttt{holds\_at}(F=V,T) :- \texttt{initiates\_at}(F=V,Ts,T),

Ts < T, not \texttt{broken}(F=V, Ts, T).

(EC2) \texttt{broken}(F=V1, [Tmin, Tmax]) :-

\texttt{(terminates\_at}(F=V1,T), Tmin < T, Tmax > T);

\texttt{(initiates\_at}(F=V2, Ti), not V1=V2, Tmin < Ti, Tmax > Ti).

(EC3) \texttt{initiates\_at}(F=V, T) :- \texttt{happens\_at}(Ev, T), Conditions[T].

(EC4) \texttt{terminates\_at}(F=V, T) :- \texttt{happens\_at}(Ev, T), Conditions[T].
Examples (I)

• Simple example

\[
\text{initiates}\_\text{at}(\text{alert}(\text{Type})=\text{message}, T) \ :- \ \text{happens}\_\text{at}(Ev, T),
\]
\[
Ev=\text{glucose}(\text{Value}),
\]
\[
\text{Value} \geq 8.
\]

• Complex rule (2 ev. 1 phy.)

\[
\text{initiates}\_\text{at}(\text{alert}(\text{Type})=\text{message}, T) \ :- \ \text{more}\_\text{than}(2, (
\]
\[
\text{happens}\_\text{at}(Ev, Tev),
\]
\[
Ev=\text{blood}\_\text{pressure}(\text{Value}),
\]
\[
\text{Value} \geq 130,
\]
\[
\text{last}\_\text{hour}(Tev, T)
\]
\[
)).
\]
Examples (II)

• Complex rule (3 ev. 2 phy.)

\[
\text{initiates\_at}(\text{alert}(\text{Type})=\text{inner\_alert}, T) :- \text{more\_than}(2, ( \\
\quad \text{happens\_at}(\text{Ev}_1, T_{ev1}), \\
\quad \text{Ev}_1=\text{blood\_pressure}(\text{Value}_1), \\
\quad \text{Value}_1 \geq 130, \\
\quad \text{last\_two\_hours}(T_{ev1}, T) \\
\)), \\
\quad \text{more\_than}(1, ( \\
\quad \text{happens\_at}(\text{Ev}_2, T_{ev2}), \\
\quad \text{Ev}_2=\text{blood\_pressure}(\text{Value}_2), \\
\quad \text{Value}_2 \geq 130, \\
\quad \text{last\_two\_hours}(T_{ev2}, T) \\
\)).
\]

• Complex and recursive

\[
\text{initiates\_at}(\text{alert}(\text{Type})=\text{outer\_alert}, T) :- \text{more\_than}(3, ( \\
\quad \text{happens\_at}(\text{Ev}, T_{ev}), \\
\quad \text{Ev}=\text{alert\_sent}(\text{inner\_alert}), \\
\quad \text{last\_two\_weeks}(T_{ev}, T) \\
\)).
\]
Conclusions

• Agents can simplify the definition of PHS
• Scalability can be improved with agents in Tier 2
• MAGPIE is based on Android
• Monitoring rules are useful in a scenario where there is no data available
• Future research:
  ➢ Web interface for rules
  ➢ Pub/sub (Tier 3)
  ➢ Evaluation: scalability and patterns in real data
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Thanks for your attention!