nano-tera.ch
swiss scientific initiative in health / security / environment systems

GDemande NTF

FNSNF

AiSlab
http://aislab.hevs.ch

Agent based Monitoring of Gestational Diabetes Mellitus

René Schumann, Stefano Bromuri, Johannes Krampf, Michael I. Schumacher

rene.schumann@hevs.ch, stefano.bromuri@hevs.ch, michael.schumacher@hevs.ch

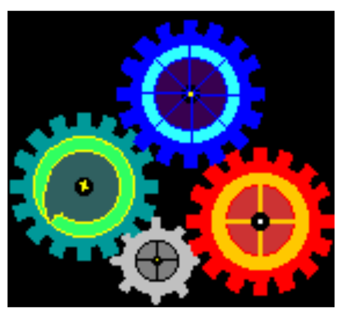
Hes·so // Valais Wallis
Haute Ecole Spécialisée de Suisse occidentale
Fachhochschule Westschweiz
University of Applied Sciences Western Switzerland

1. Our Motivation: Gestational Diabetes

- **Gestational diabetes mellitus (GDM) is a condition that affects 2-5% of all the pregnancies and manifests itself with high blood sugar levels during pregnancy.**
- **It can cause health problems for mother and child like,**
  - **Preeclampsia, Eclampsia,**
  - **Hyperglycemia,**
  - **Macrosomia, and**
  - **Diabetes type II**
- **Current treatment practices: Doctors usually see patient 2-3 times a week. In case of hyperglycemia, the patient may arrive too late.**

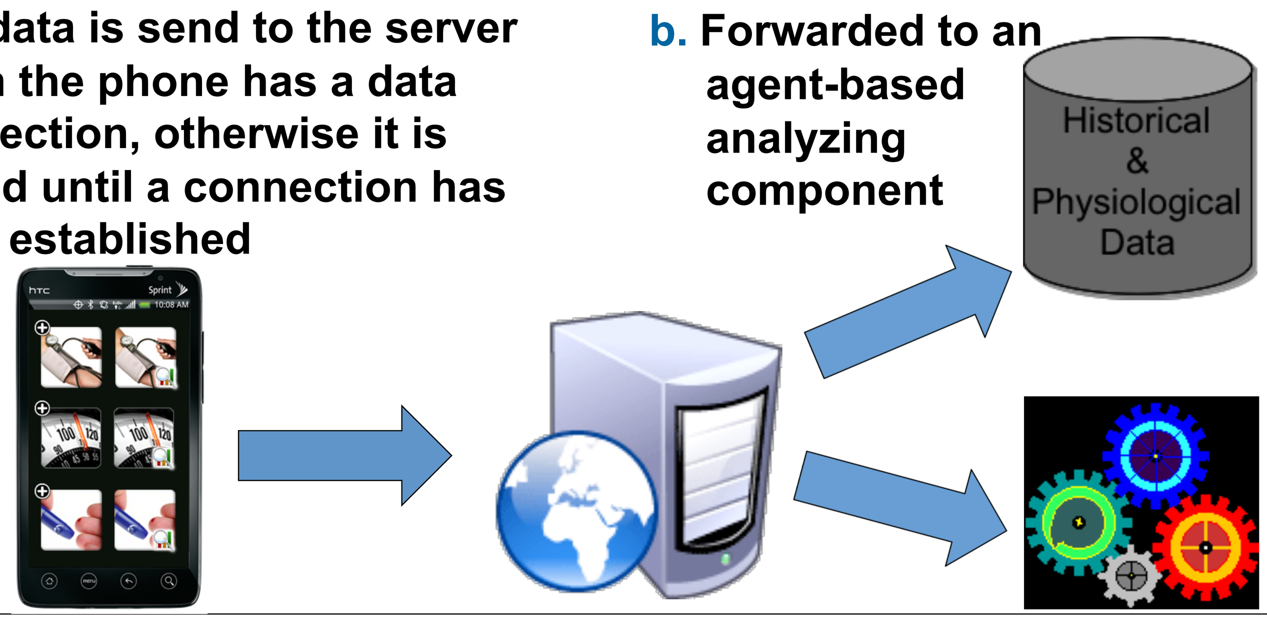
2. Our Goals: Improve the Level of Care

- **Goal of our system**
  - **Improve the care level of the woman**
  - **React faster to the development of possible life-threating conditions.**
- **Means to do so:**
  - **Pervasive Health Systems for acquiring data**
  - **Multi-Agent System for reasoning about the data**

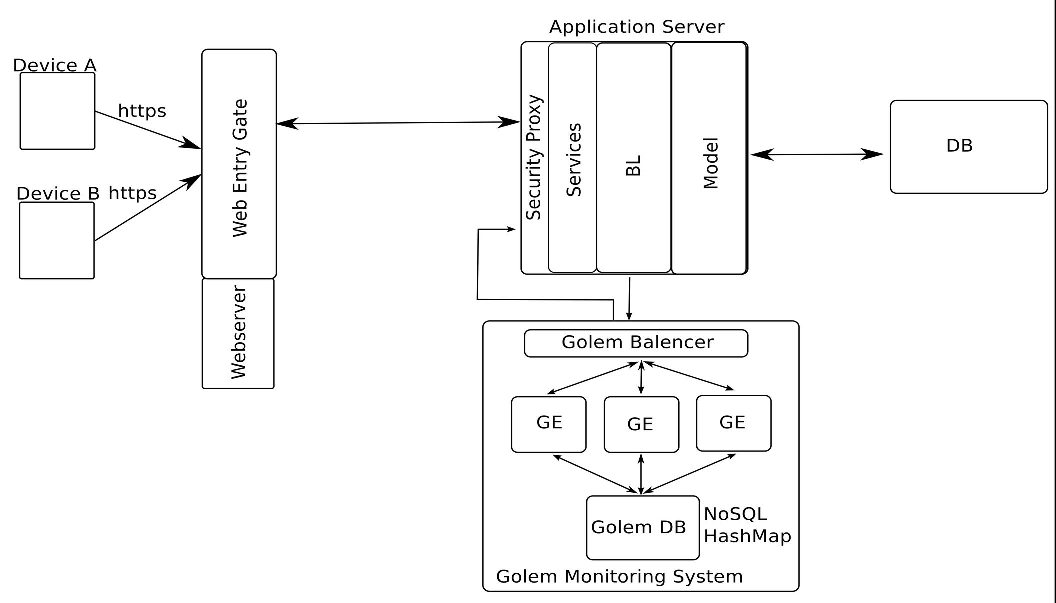


3. The Pervasive Healthcare System

- **Patients can enter their physiological values, using an mobile App developed in the project**
- **The data is send to the server when the phone has a data connection, otherwise it is stored until a connection has been established**
- **Incoming patient data is**
  - **a. Stored in a database**
  - **b. Forwarded to an agent-based analyzing component**

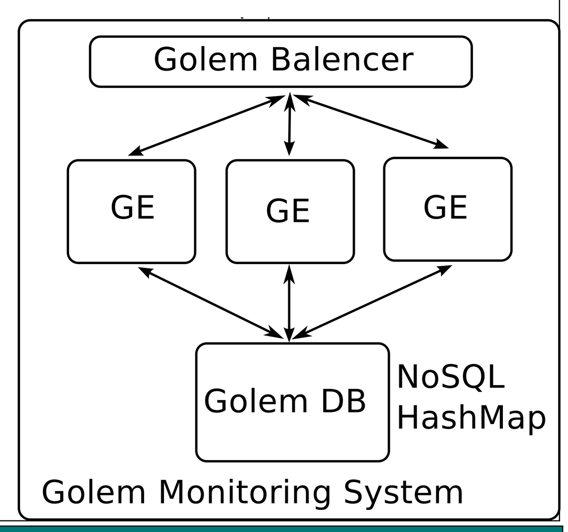


- **Architecture of the Service Infrastructure**



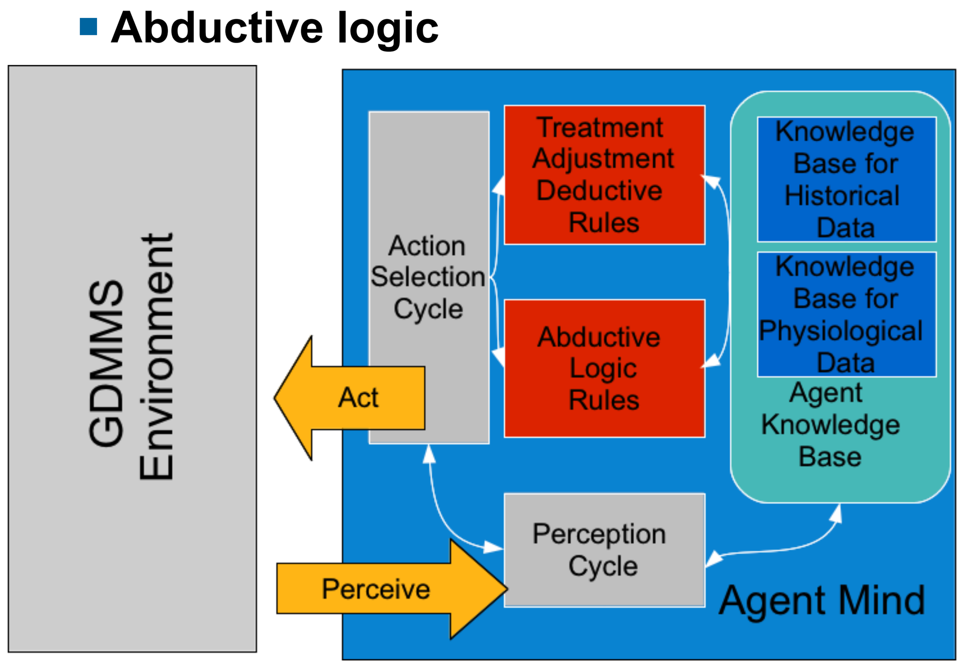
4. The Multiagent System

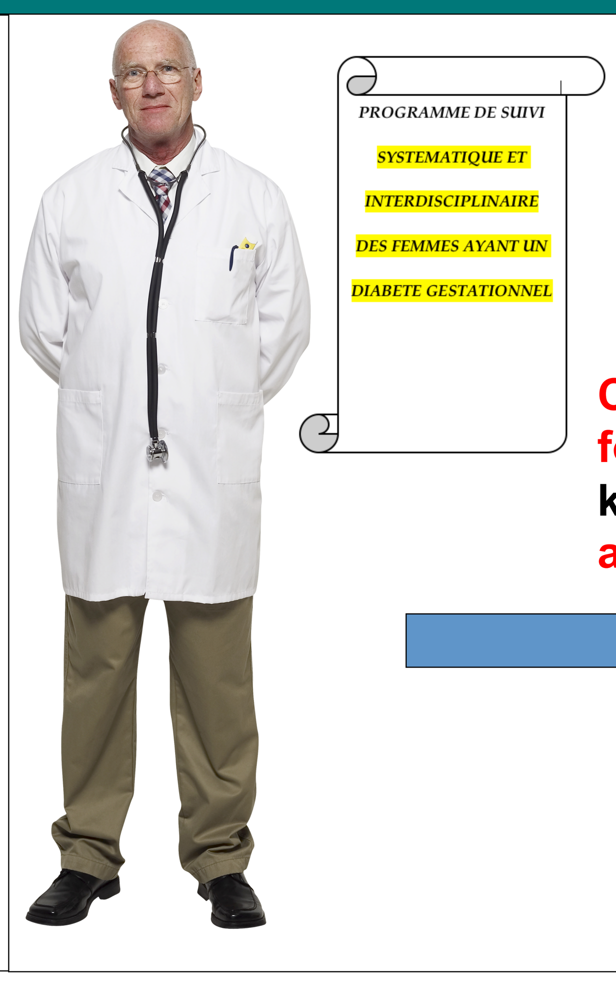
- **An agent is responsible for monitoring one patient**
- **To scale-up, the agents can be:**
  - **distributed on different nodes;**
  - **activated and deactivated by a balancer;**
  - **persisted in an agent database.**



4. The Multiagent System (continuation)

- **Each agent has capabilities to efficiently reason about recognized Events.**
- **Medical conditions can be declared in terms of**
  - **Deductive logic**
  - **Abductive logic**





Capturing and formalizing medical knowledge to allow for automated analysis

Abductive Rules

```
DomainKnowledge :
previous_macrosomia ← macrosomia.
week_of_gestation(W)← W >= 34, macrosomia; W >= 20, preeclampsia.
glucose_observation(A = [Gl1,Gl2, . . . Gl20]) ←
    ∃ Glk,Glj ∈ A, j ≠ i, Glk >5, Glj >5, macrosomia.
previous_preeclampsia; blurred_vision; severe_headache;
    lower_leg_oedema← preeclampsia; severe_preeclampsia.
kidney_disease; oliguria; protenuria; nausea; epigastric_pain ←
    preeclampsia; severe_preeclampsia.
blood_pressure(Systolic, Diastolic)←
    preeclampsia,protenuria, Systolic >= 140, Diastolic >= 90;
    not protenuria,severe_hypertension,Systolic>=160,Diastolic>=110;
    Systolic>=140,Diastolic>=90,protenuria,week_of_gestation(W),W < 35,
    (severe_headache;blurred_vision;nausea;vomiting),severe_preeclampsia.
IC :
    ← preeclampsia, (not protenuria;week_of_gestation(W), W < 20).
    ← protenuria, severe_hypertension.
    ← preeclampsia, blood_pressure(S,D),S < 140, D < 90.

select(Symptoms, A, T)←
  demo(Symptoms, Explanation),instance_of(ID,patient,T),myID(AID),
  member([preeclampsia], Explanation),full_piers(ID,Probability,T),
  A= store_event:act2[actor⇒ AID,physiological_data:ph2[type⇒observation,
                 timestamp ⇒ T, value ⇒ Probability:preeclampsia]].

full_piers(ID,Probability,T)←holds_at(ID,platelet,PLA,T),holds_at(ID,spo2,SPO2,T),
  holds_at(ID,creatinine, CRE, T),holds_at(ID,aspartate, AST,T),
  holds_at(ID,gestational_age, Age,T),holds_at(ID,chestpain, Pain,T),
  Coeff = 2.68 + (-5.41*10^-2*Age) + 1.23*Pain + (-2.71*10^-2*CRE) +
  (2.07*10^-1*Plat) + (4*10^-5*Plat^2) + (1.01*10^-2*AST) +
  (-3.05*10^-6*AST^2) + (2.50*10^-4*CRE*PLA)+ (-6.99*10^-5*PLA*AST) +
  (-2.56*10^-3*PLA*SPO2), Probability is exp(Coeff)/1+exp(Coeff).
```

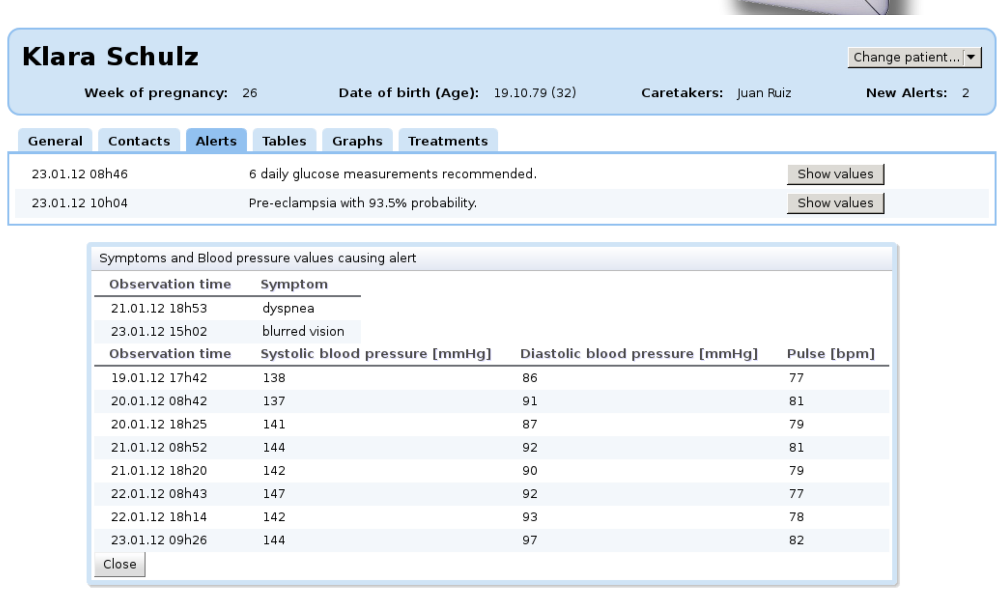
Deductive Rules

```
R1) terminates(glucose_observation:Ev, ID, observations, _).
R2) initiates(glucose_observation:Ev,ID,observations,[Ev|Tail])←
      patient_of(Ev,ID), time(Ev,T), holds_at(ID,observations, Tail, T).
R3) initiates(glucose_observation:Ev,ID,hypoglycemia_risk, true)←
      patient_of(Ev, ID), time(Ev,T), holds_at(ID,observations, List, T),
      size(List, 20),not (member(M, List), glycemia(M,Gl), Gl >4).
R4) initiates(glucose_observation:Ev, ID, hypoglycemia_risk, true)←
      patient_of(Ev, ID),glycemia(Ev, Gl),time(Ev,T),
      holds_at(ID,observations, [Head|Tail], T), time(Head,T*),
      T - T* < 1, glycemia(Head, Gl2), Gl < 3, Gl2 < 3.
R5) initiates(glucose_observation:Ev,ID,postprandial_observation,[Ev|Tail])←
      is_postprandial(Ev),time(Ev,T),patient_of(Ev, ID),
      holds_at(ID,postprandial_observation, Tail, T).
R6) initiates(glucose_observation:Ev,ID,introduce_preprandial,true)←
      is_postprandial(Ev),time(Ev,T),patient_of(Ev,ID),
      holds_at(ID,postprandial_observation, List, T),
      sublist(Sub,List), size(Sub,6),foreach(Obs,Sub,(glycemia(Obs,G),G>8)).
select(_,A,T)←instance_of(P, patient,T),holds_at(P,introduce_slow_insuline,true,T),
  myID(ID),A=store_event:a1[actor⇒ID,recommendation:p1[
                 timestamp ⇒ T, value ⇒ introduce_slow_insulin]].
```

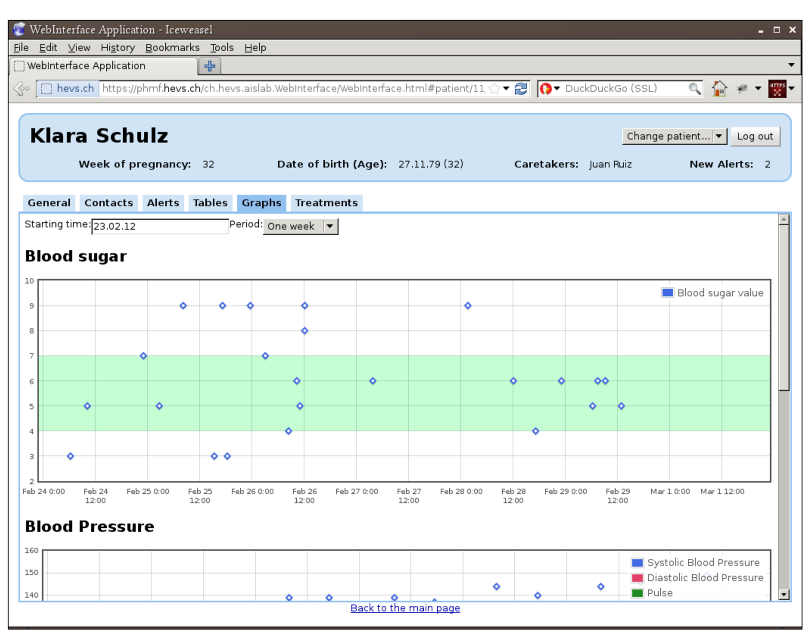
5. The Web Interface

- **If an alert occurs:**
  - **The doctor in charge gets notified via E-Mail**

- **He can see all details at the Web interface**



- **Graphs and tables help to access patients data.**



6. Status of the project

- **Field tests will start in the second half of 2012**

CHUV

- **Patients will be given a smart phone to monitor their condition for three month each.**

- **The agent system will be also used in the Commodity12 project (funded by the EU)**

COMMODITY12
COntinuous Multi-parametric and Multi-layered Analysis Of DIabetes TYpe 1 & 2