



On the application of multi-agent systems in health care

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Sevilla, June 14th-15th 2010

Outline of the talk

- Introduction
 - **Health care areas** where agents have been applied
 - **K4Care**: agent-based provision of Home Care services
 - **Benefits** of the application of agents in health care problems
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Characteristics of Health Care problems

- **Distributed knowledge**
 - E.g. different units of a hospital
 - **Coordinated effort**
 - E.g. receptionist, general and specialised doctors, nurses, tests personnel, ...
 - **Complex problems**
 - E.g. patient scheduling
 - **Need to manage different types of knowledge**
 - Medical, organisational, procedural
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Why use MAS in Health Care?

- MAS are inherently **distributed**
 - Agents can **coordinate** their activities, while keeping their autonomy and local data
 - Dynamic and flexible distributed **problem solving** mechanisms
 - Use of **personalisation** techniques
 - Knowledge-based behaviour of the system
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Main application domains

1-Medical data management

National electronic Library for Health (NeLH)

Management of palliative patients (PalliaSys)

Virtual Electronic Patient Record (VEPR)

Context-aware Hospital Information System (CHIS)

3-Planning and resource allocation

Agent.Hospital (simulation)

CARREL (transplant management)

Medical Information Agents (MIA)

Medical Services Coordination (MeSSyCo)

5-Composite Systems

SHARE-IT (assistive technologies)

K4Care (Home Care)

Geriatric Ambient Intelligence (GerAml)

2-Decision support systems

Singh's intelligent assistant

HealthAgents [Microart]

Health Care Services (HeCaSe)

4-Remote care, telemedicine

Aingeru (elder monitoring)

INCA (Community services)

Medical Contact Centres [Koutkias]

Monitor chronic patients [Cervantes]

1-Medical data management

- This area includes different kinds of systems:
 - **Information agents** that collect, filter and analyse medical information available in electronic resources
 - Agents that provide a transparent access to **physically distributed information sources**
 - Different medical organisations, or different units within a hospital
 - In general, intelligent management of the personal and medical information in the **Electronic Health Record** of a patient
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2-Decision support systems

- These systems aim to **assist the professionals** in the decisions to be taken during the healthcare process.
 - E.g. help in the diagnosis phase, or in the definition and execution of the most appropriate personalised treatment.
 - Agents can also perform **routine actions**, such as checking periodically the patient state, or waiting for the results of a medical test to be available
 - They usually perform complex **reasoning** processes
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3-Planning and resource allocation

- Systems in which **professionals and/or medical resources** are represented by autonomous agents
 - The basic aspect is the **coordination** of their activities to take appropriate decentralised scheduling decisions in medical centres
 - E.g. patient scheduling
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4-Remote care, Telemedicine

- In most cases, the basic aim of the system is to **monitor continuously the state of the patients**, allowing permanent care
 - Main elements of the system:
 - Collection of **sensors**
 - **Analysers** of signals from sensors, problem detection
 - **Generation of alarms** and reports for medical staff
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5-Composite systems

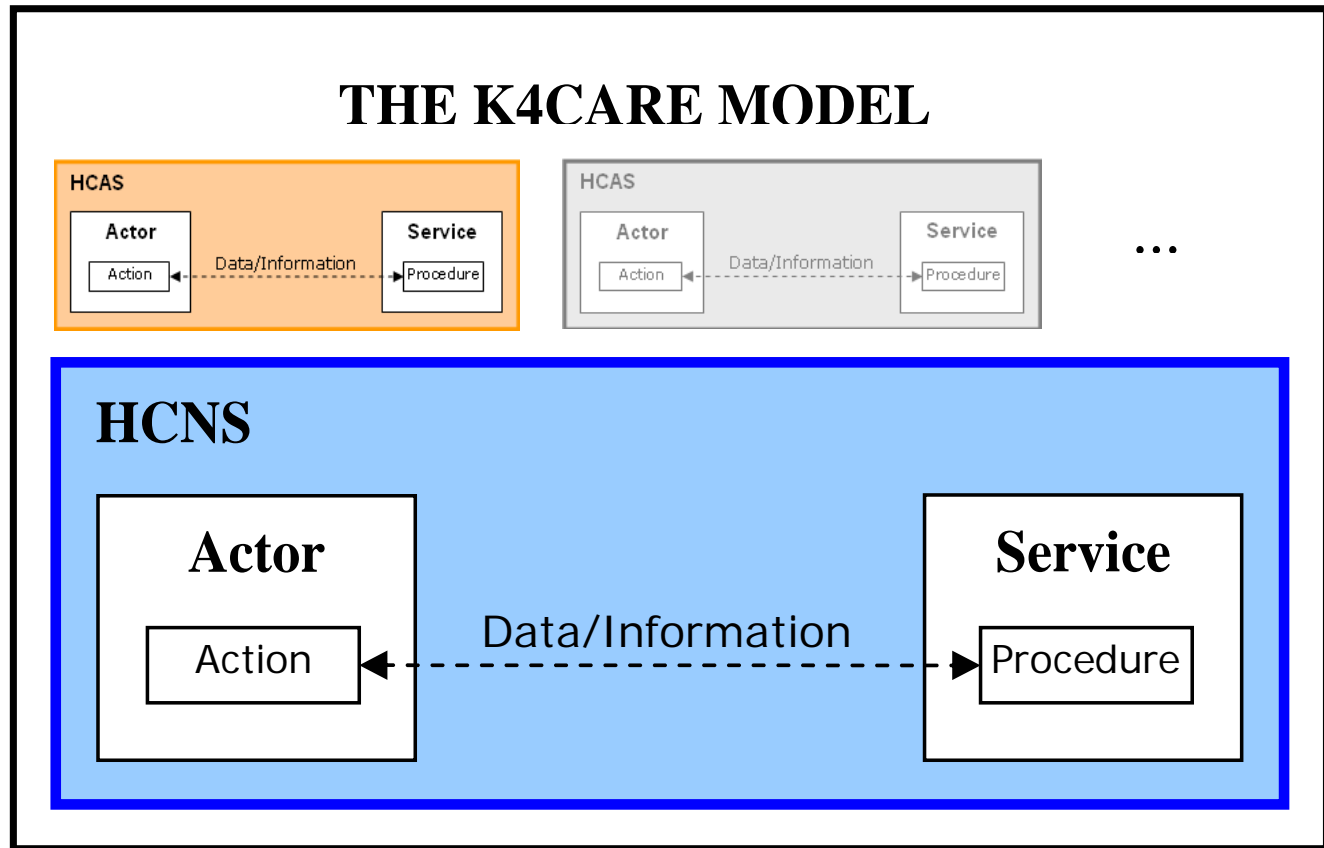
- **Agent-based platforms** that **integrate** different ICTs and Artificial Intelligence techniques in order to provide an efficient coordination of the activities to be performed to provide an efficient health care to a particular kind of patients
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K4Care European project

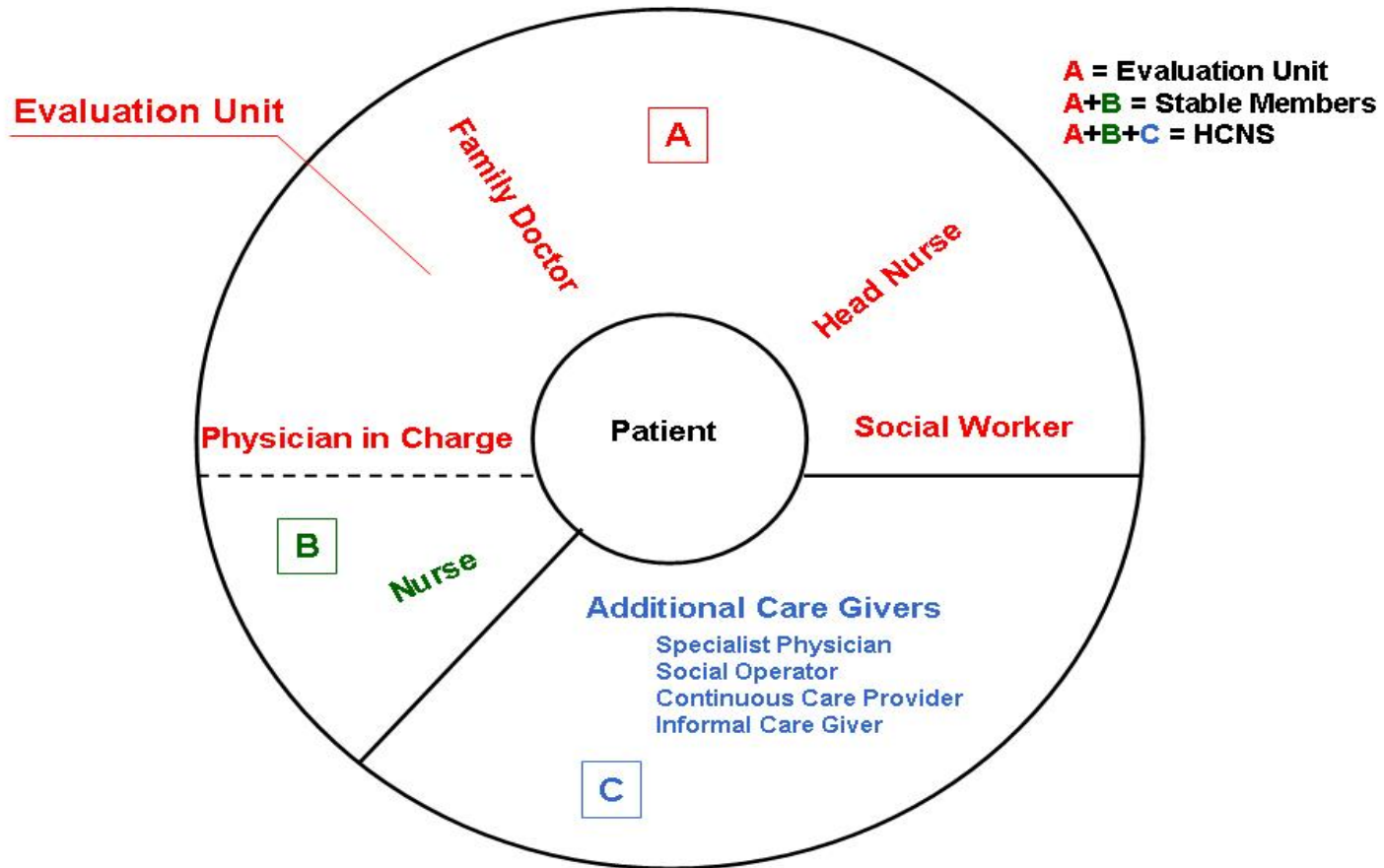
- 2006-2009, 13 partners, coordinated by URV
 - The aim of the K4Care European project was to **provide a *Home Care model***, as well as to develop a **prototype system**, based on **Web technology and intelligent agents**, that provided the services defined in the model
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K4Care Model: Structure

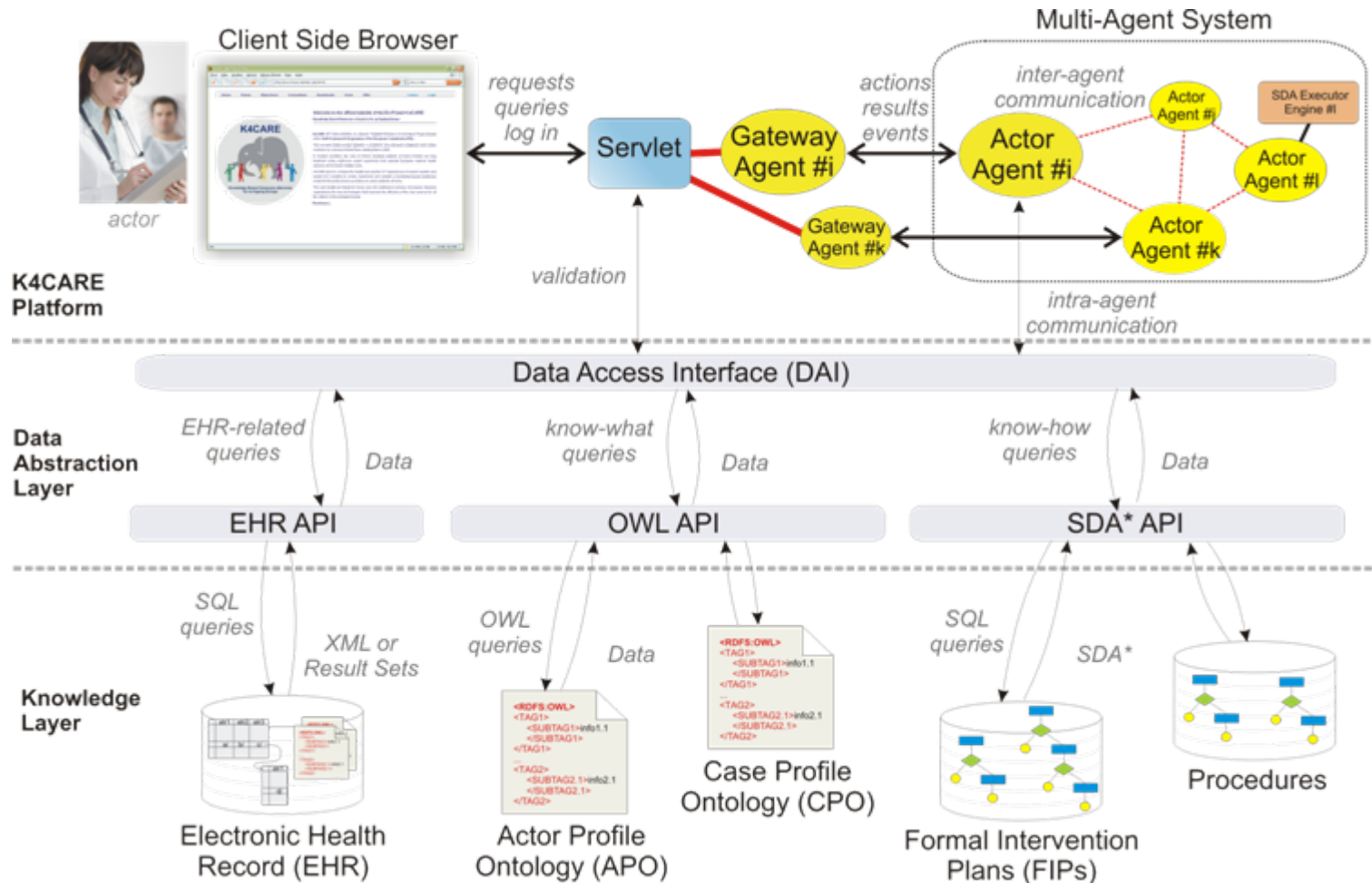
- 1 Nuclear Structure + n Accessory Services



K4Care Model: Actors and Teams



K4Care architecture



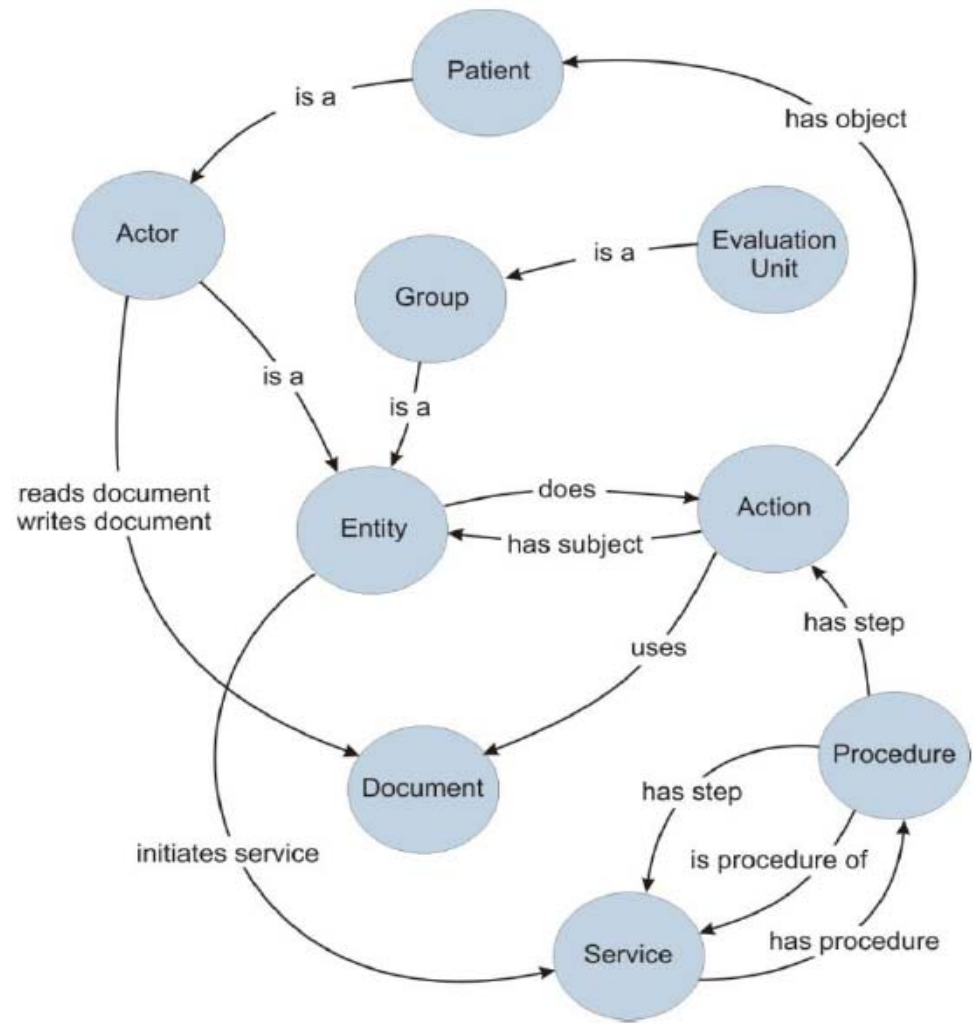
K4Care Knowledge structures

- EHCR: Electronic Health Care Record
 - APO: Actor Profile Ontology
 - CPO: Case Profile Ontology
 - Procedures
 - FIP: Formal Intervention Plan
 - IIP: Individual Intervention Plan
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K4Care Ontologies (I)

■ Actor Profile Ontology (APO)

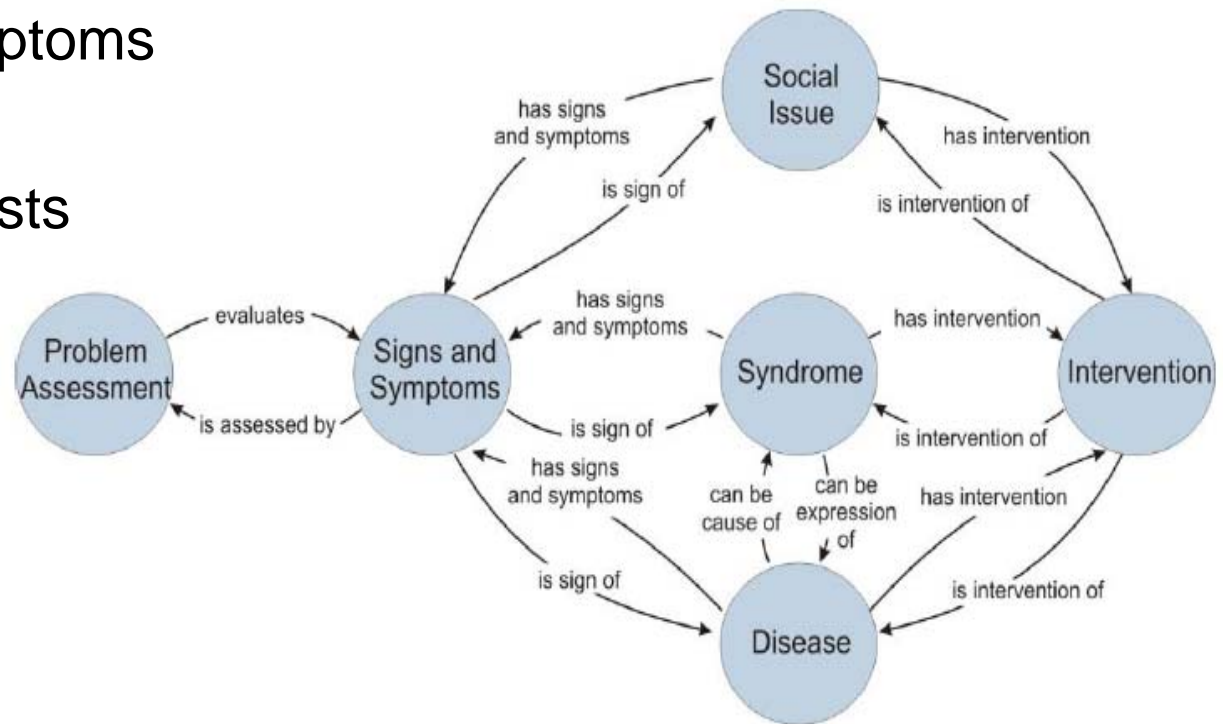
- Types of actors
- Actions related to each role
- Platform services
- Procedures
- Documents
- ...



K4Care Ontologies (II)

■ Case Profile Ontology (CPO)

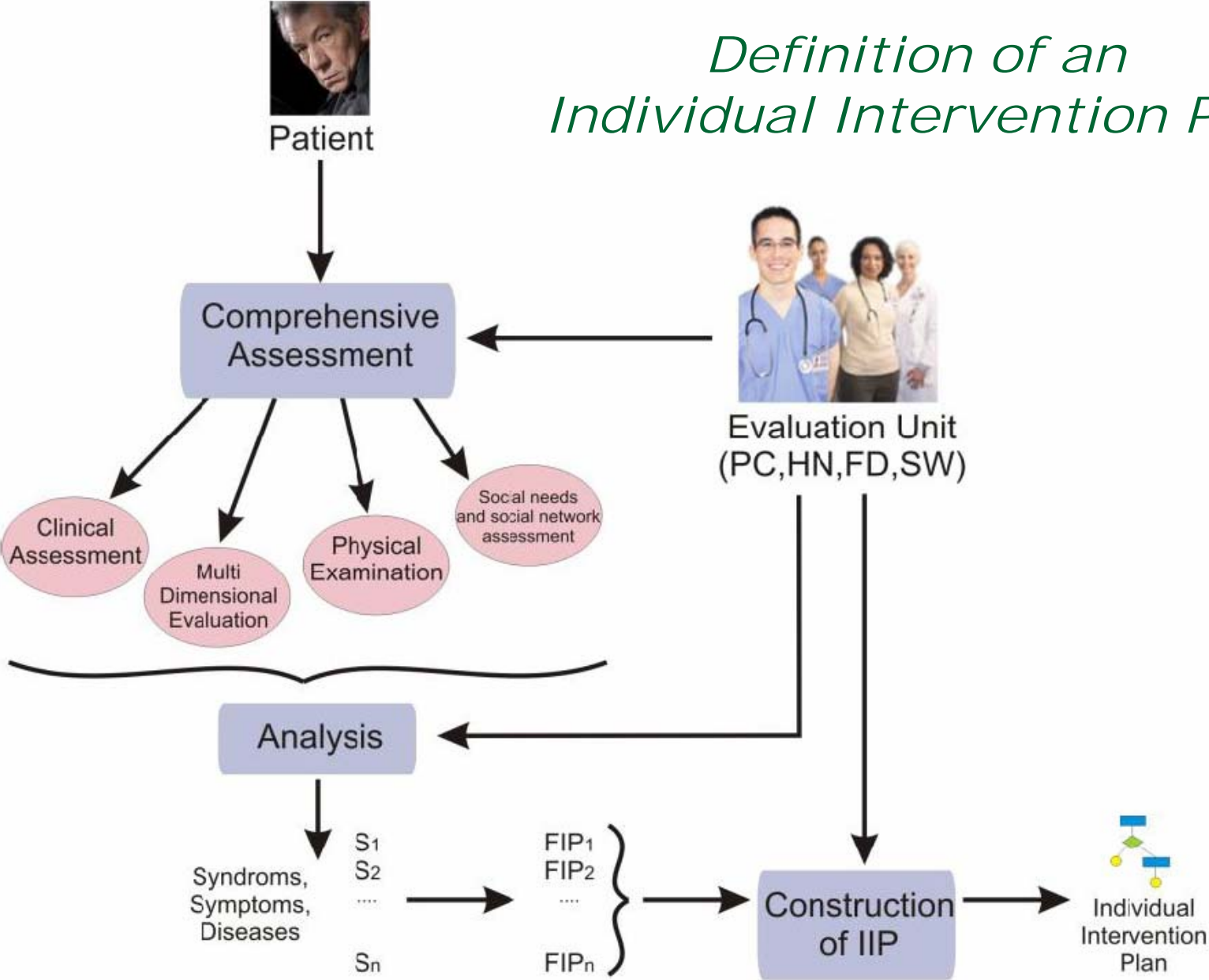
- Diseases
- Syndromes
- Signs and symptoms
- Social issues
- Assessment tests
- Interventions
- ...



Procedures, FIPs and IIPs

- All the **careflow procedural aspects** are represented in **SDA*** (States, Decisions, Actions)
 - **Procedures** are formal specifications of the way in which an **administrative service** (e.g. *admit a new patient to the Home Care service*) has to be implemented
 - **Formal Intervention Plans (FIPs)** are formal structures representing the **health care workflow** to assist patients suffering from particular ailments or diseases
 - **Problem: application of guidelines to co-morbid patients**
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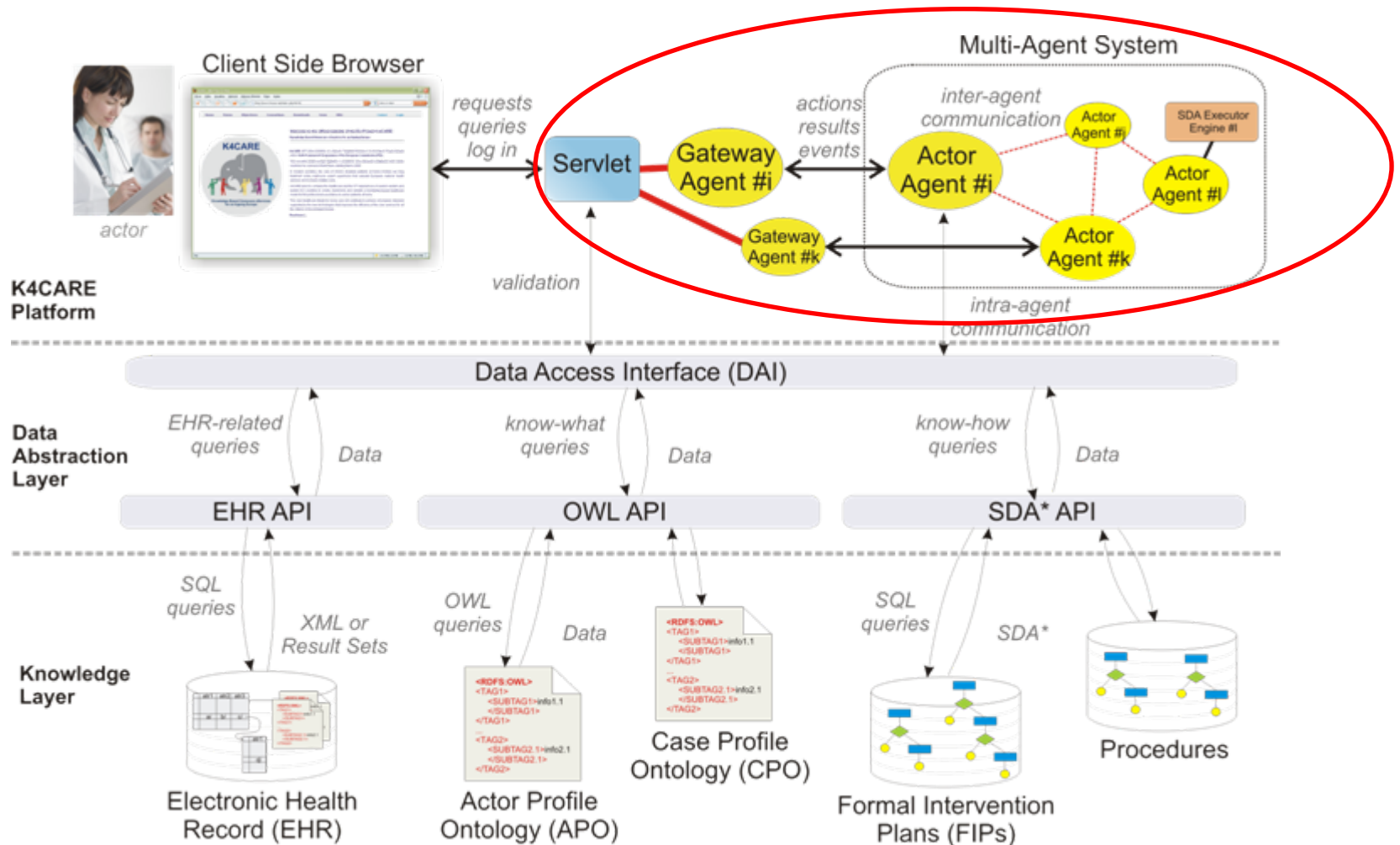
Definition of an Individual Intervention Plan



K4Care platform features

- Agent-based Web-accessible platform that provides a set of **basic Home Care services**
 - Admit a patient to the Home Care service
 - Create an Evaluation Unit
 - Assign an Evaluation Unit to a particular patient
 - Assess the initial state of a patient
 - Definition of an IIP for a patient
 - Apply IIP to the patient
 - ...
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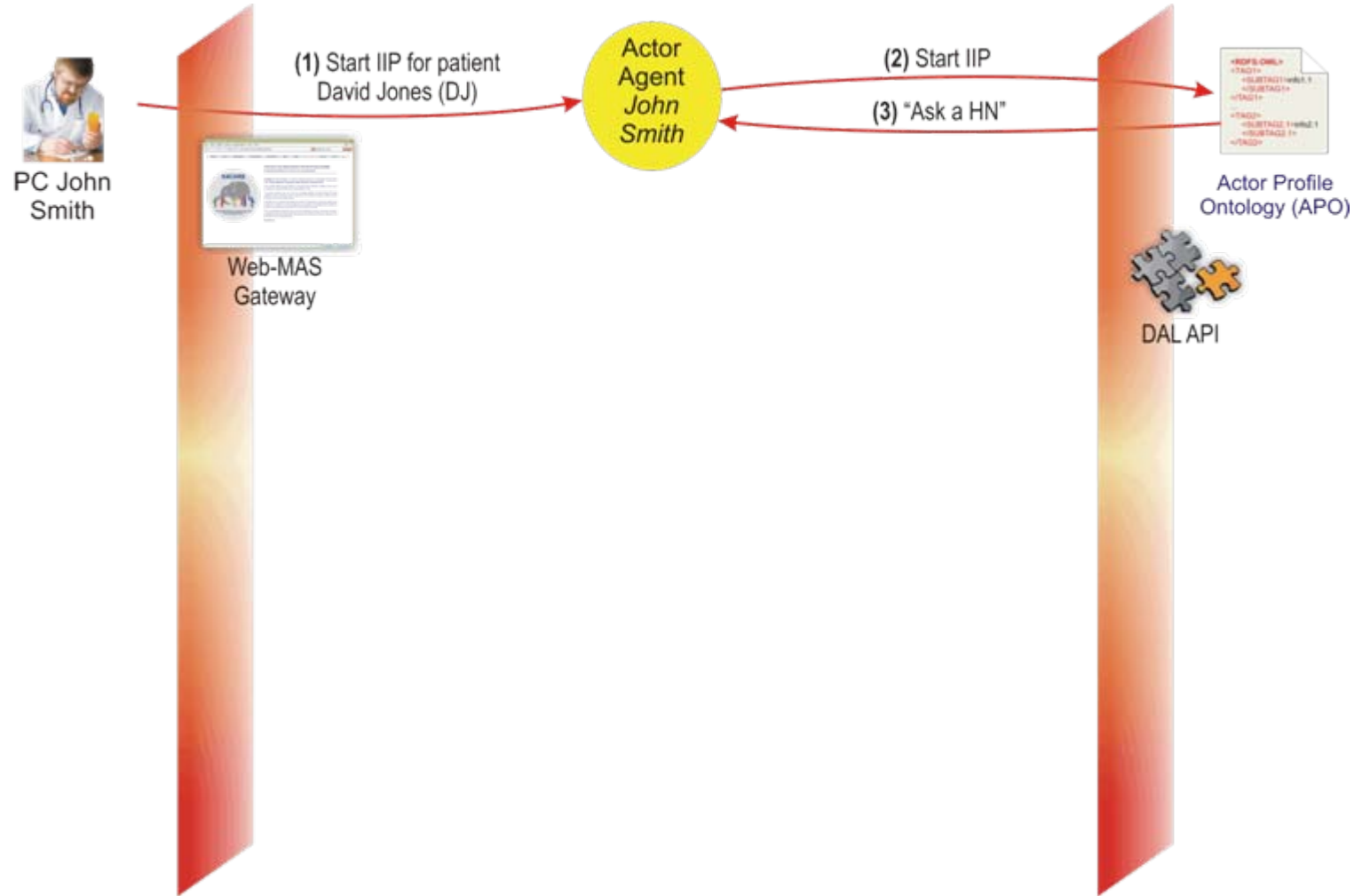
K4Care agent-based platform



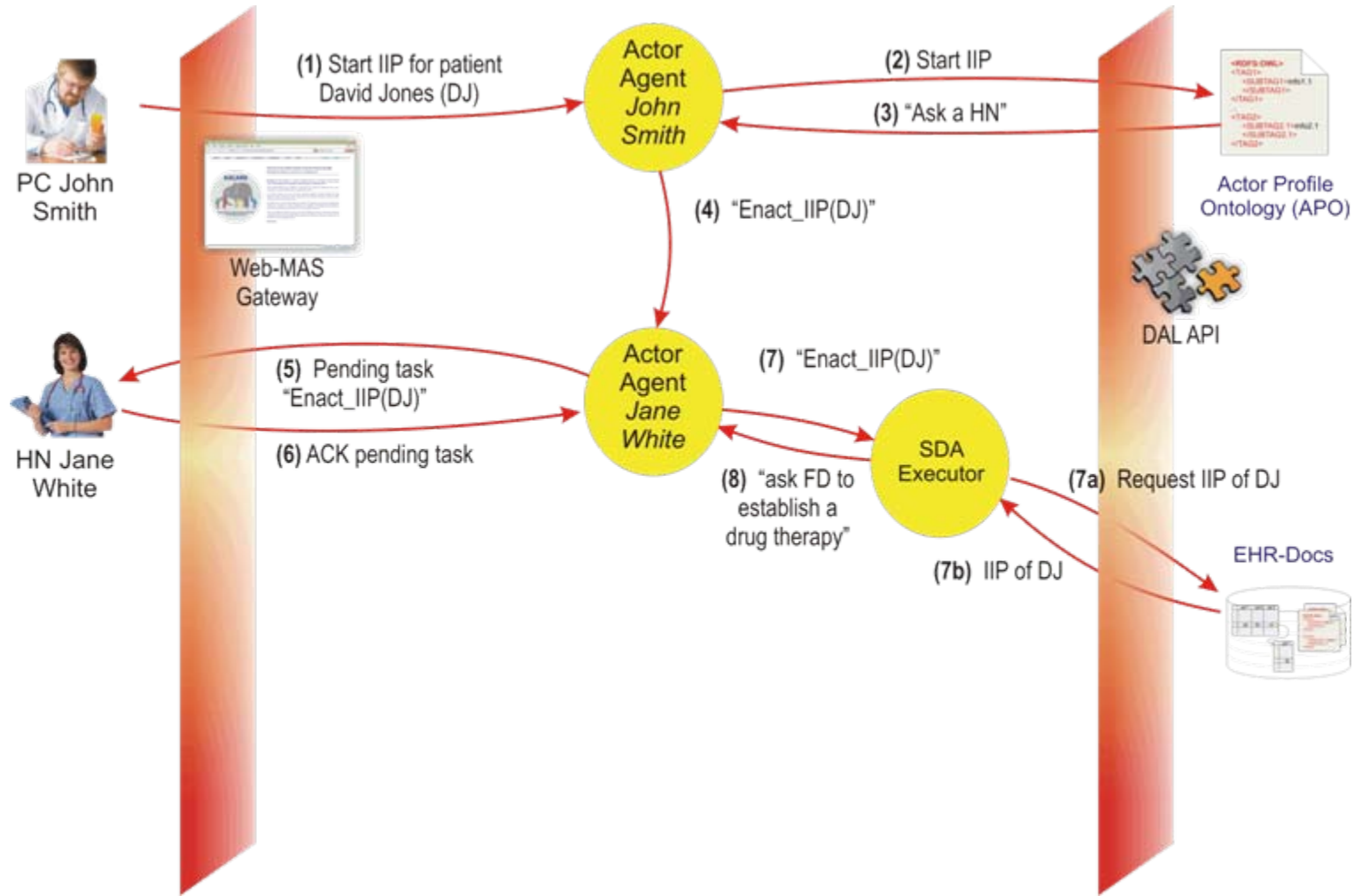
Multi-agent system

- 1 **Actor Agent** for each user, permanently running
 - When the user logs in, a **Gateway Agent** is dynamically created
 - Two-way communication **Web-servlet-GA-AA**
 - When an Actor Agent has to manage the execution of a procedure/IIP, it creates dynamically a **SDA-executor Agent**
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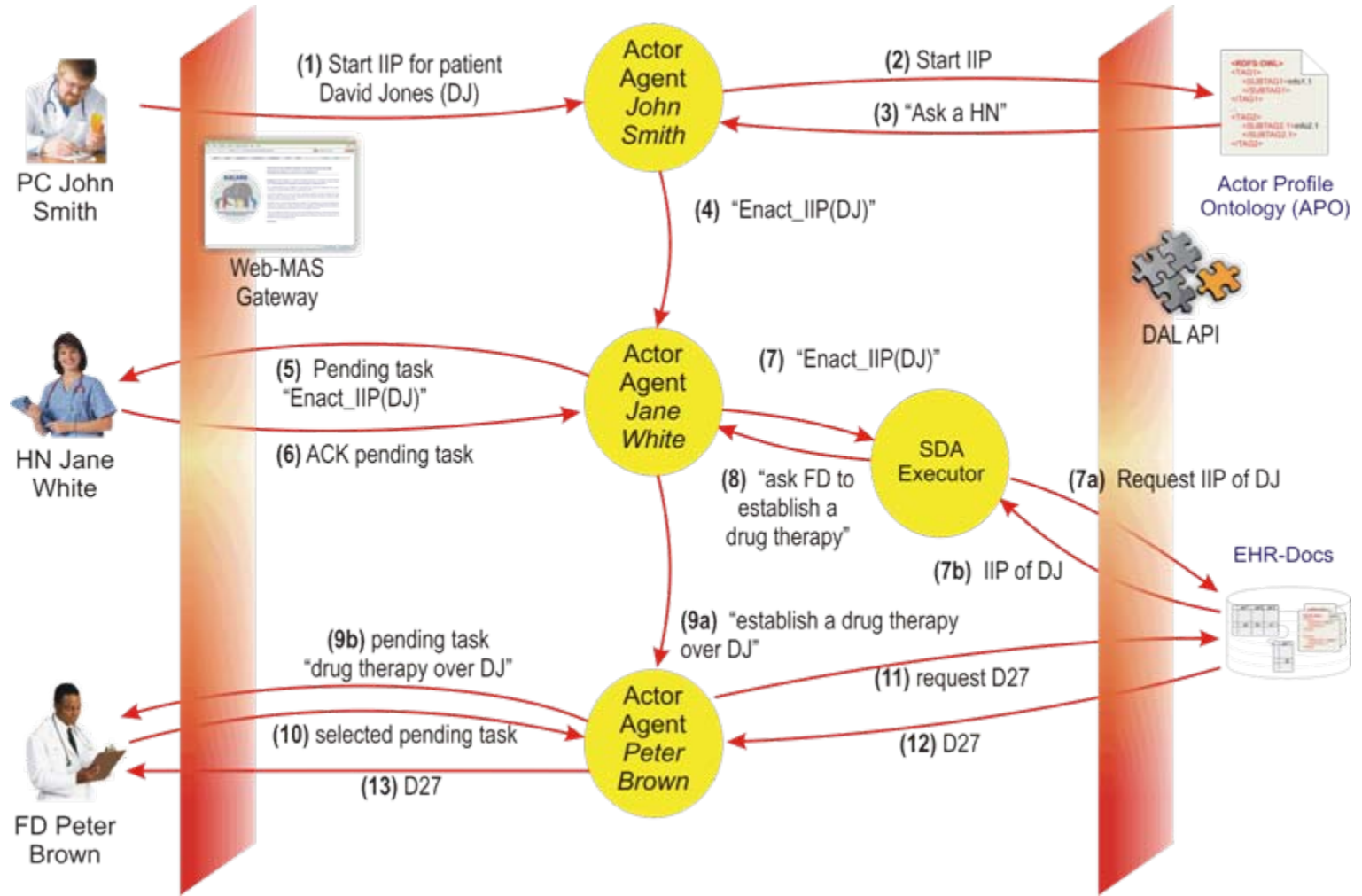
Agent-based execution of IIPs (I)



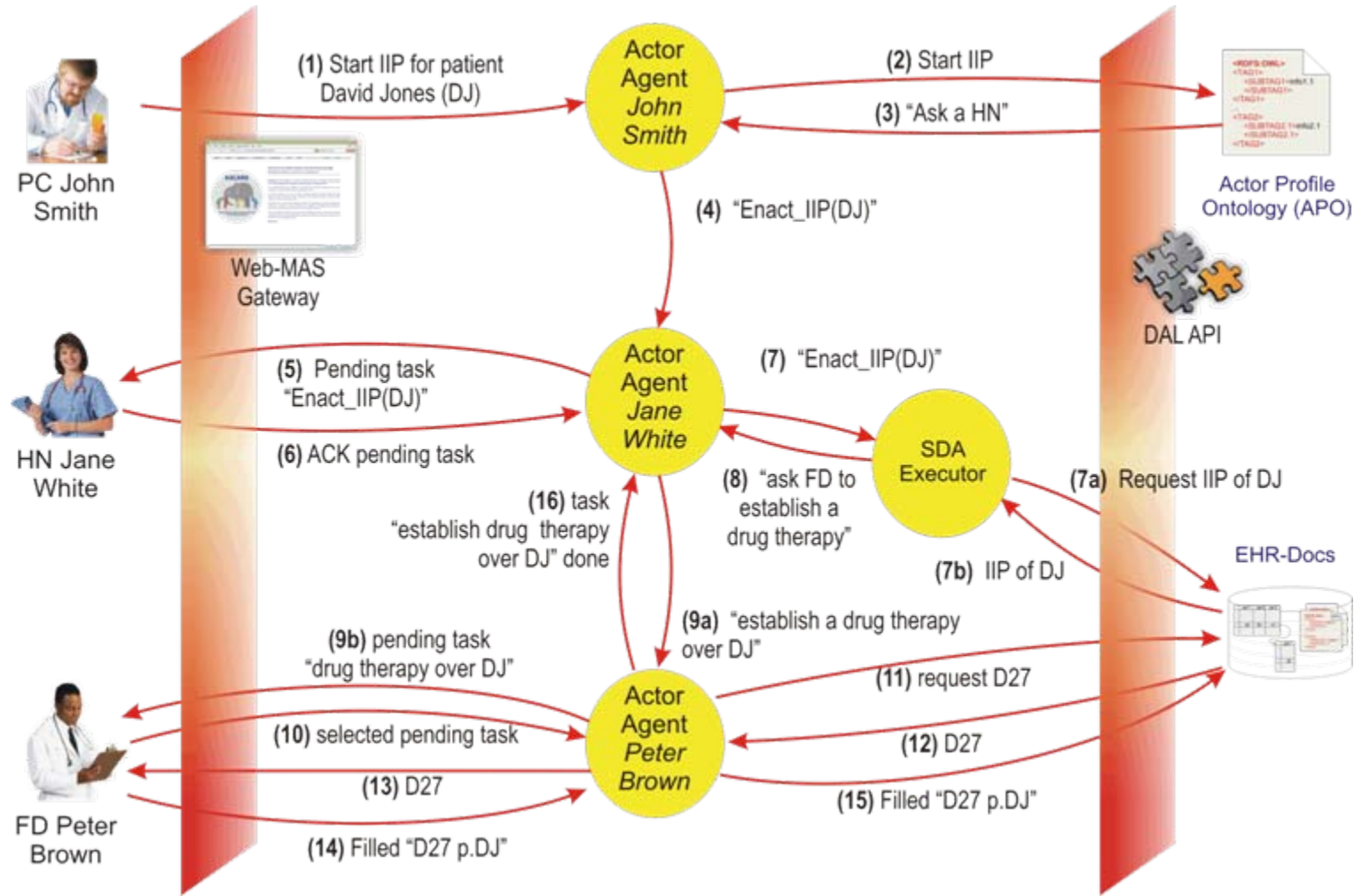
Agent-based execution of IIPs (II)



Agent-based execution of IIPs (III)



Agent-based execution of IIPs (IV)



Summary of K4Care main aspects

- **Declarative** (medical, organizational) and **procedural** knowledge
 - **Web-based interaction** between agents and end-users
 - **Individual Intervention Plans** allow practitioners to implement accurate and personalised sequences of actions for the treatment of a particular patient
 - The architecture allows implementing **agent-based coordination methods** between the actors relevant in Home Care, which **adapt their behaviour dynamically** depending on the knowledge available in the platform
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Positive aspects of MAS [in HC] (I)

■ Modularity

- A complex problem is divided in subproblems which may be solved by autonomous units, with the appropriate coordination among them

■ Efficiency

- Agents may be running in different computers, speeding up the resolution of the problem

■ Decentralisation

- Less single point-of-failure risk than centralised systems
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Positive aspects of MAS [in HC] (II)

■ Flexibility

- The MAS components may change at run time, the tasks may be dynamically distributed

■ Personalisation

- Personal agents may have information on the user preferences and adapt the system's behaviour to them

■ Distributed planning

- Use of coordination techniques for distributed problem solving
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Positive aspects of MAS [in HC] (III)

- **Monitoring, alarm management**
 - Continuous monitoring of personal and medical data, with immediate activation of emergencies when needed
 - **Proactivity**
 - Agents may perform tasks without requiring a constant intervention or request from the user
 - **Security**
 - Confidentiality of medical data
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Recommended extra material

- Publications at <http://deim.urv.cat/~itaka>
- D.Isern, D.Sánchez, A.Moreno

Agents applied in health care: a review

International Journal of Medical Informatics, Vol. 70, pp. 145-166, 2010

INTERNATIONAL JOURNAL OF MEDICAL INFORMATICS 79 (2010) 145-166



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journal homepage: www.intl.elsevierhealth.com/journals/ijmi



Review

Agents applied in health care: A review

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Agents – general definition

- Computational entities, capable of sensing the environment and acting **proactively** and **autonomously** upon it in order to satisfy their design objectives
 - Can **communicate** with other agents to share information, **coordinate** their activities and cooperate to solve complex **distributed** problems
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DBs, Electronic Health Care Record

- **Data Base**: with information about the K4Care actors as users of the K4Care Platform (e.g. contact information)
 - **EHCR**: with the data about the Home-Care processes performed within the K4Care Platform
 - Medical documents stored in XML
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FIP for the management of hypertension

