

Enabling collaborative eHealth through Triple Space Computing



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Acknowledgement



The research mentioned in this talk is supported by the EU STREP TripCom!

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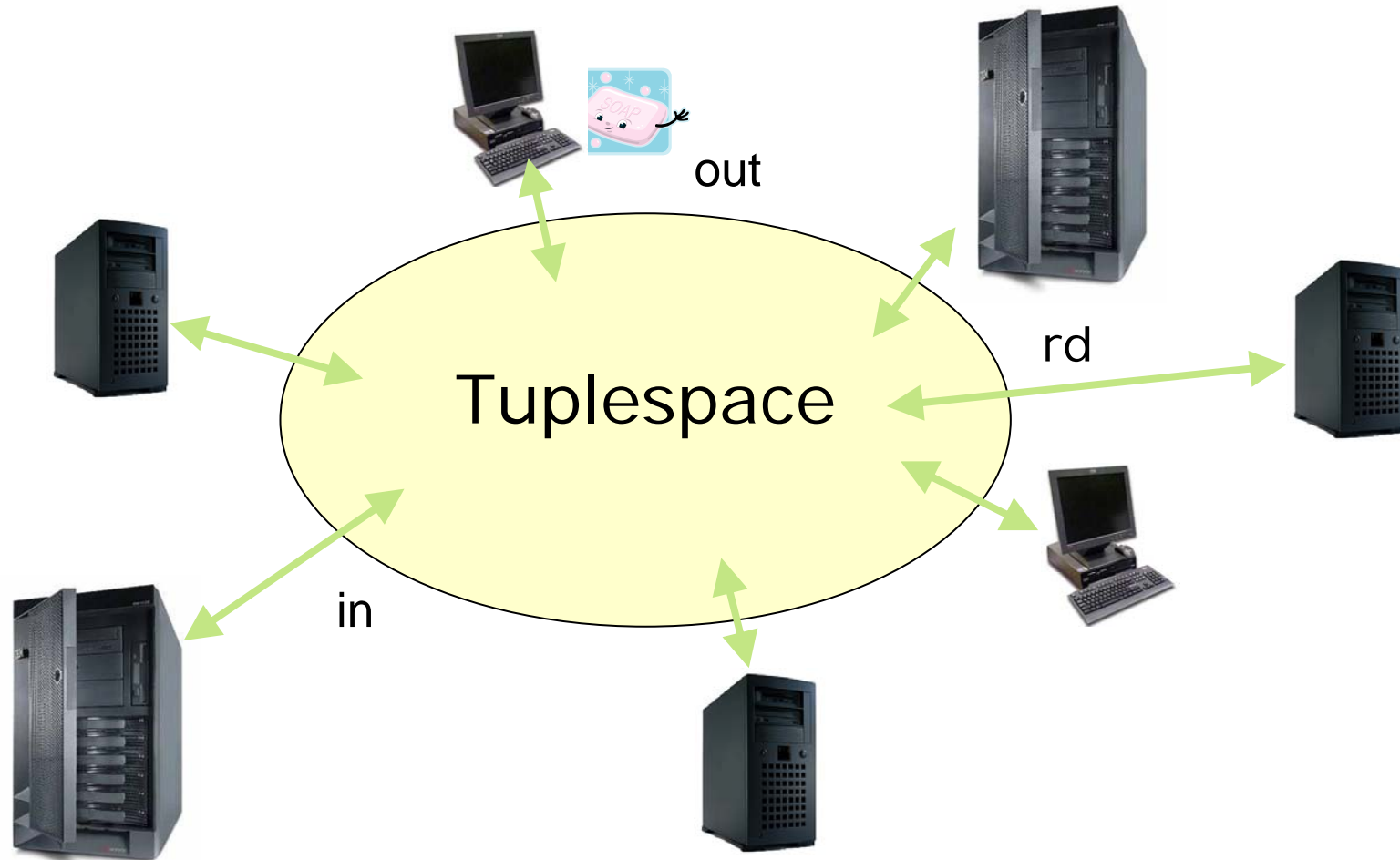
TRIPLE SPACE COMMUNICATION
This is the official Website of the Specific Targeted Research Project TripCom. TripCom is to be funded by the European Commission under the 6th Framework Programme, priority 2 Information Society Technologies (IST) under the project number IST-4-027324-STP.

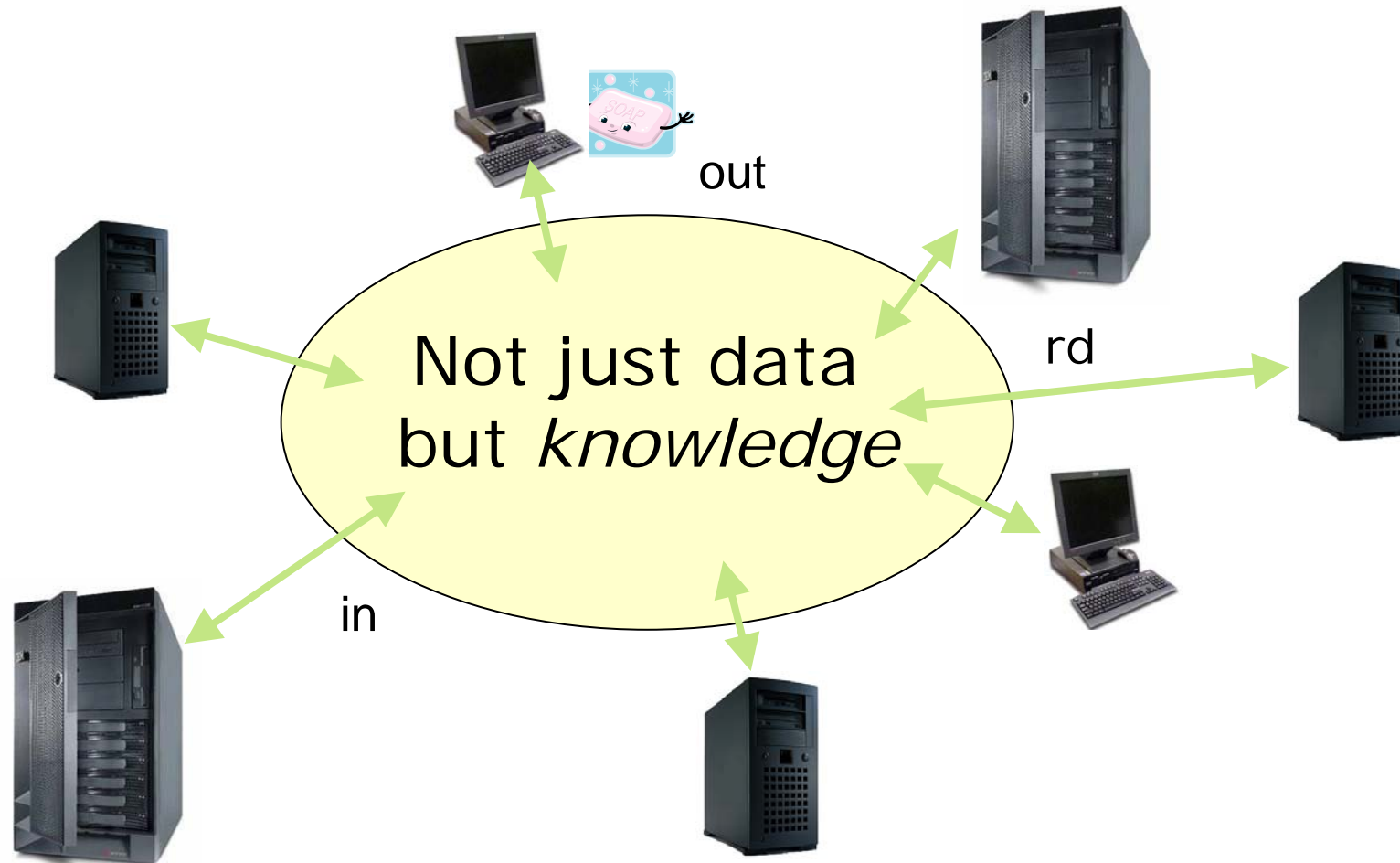


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 - Semantic Web
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 - Triple Space Coordination, API
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Background

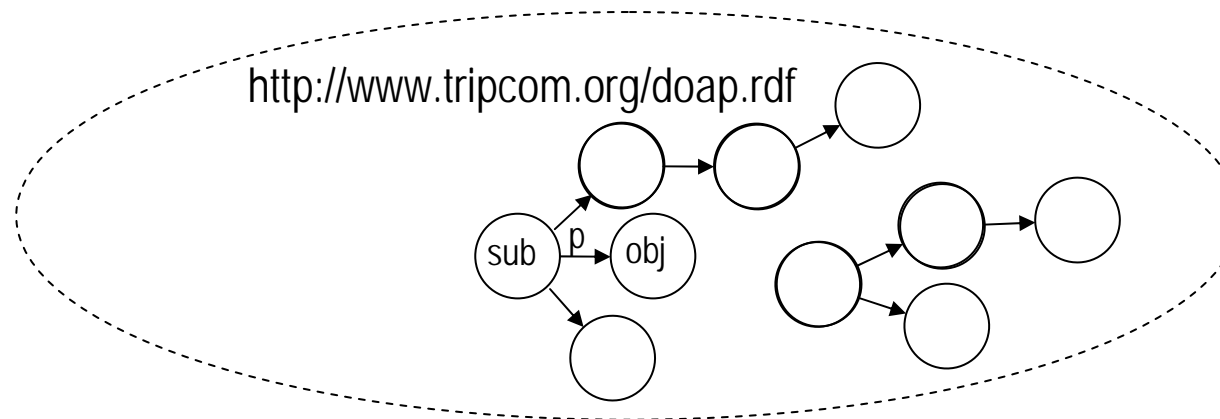
Classical Coordination





RDF is the lingua franca of the Semantic Web

RDF data model consists of **triples**: statements of knowledge of the form subject, predicate and object, each given an unique URI



Statements together form a (labelled directed) graph

A graph with an identifier (URI) is a **named graph**

- RDF based on logical theory
 - From sets of RDF statements, a reasoner can **infer** new knowledge
- RDF moving from academia into the real world Health & Life Sciences is a key domain for use of Semantic Web
- No co-ordination approaches have yet been established to control concurrent access to knowledge

- Started with a simple observation that RDF could be modelled in a tuple of form $\langle s, p, o \rangle$
 - TSC

- Previous work had placed all semantic data as a document in a single tuple field
 - sTuples

- TripCom also learns from other, more specialised work on RDF tuplespaces
 - cSpaces, Semantic Web Spaces (more later...!)

Results

Triple Space Computing refers to the combination of tuplespaces, Semantic Web and Web Services to enable the co-ordinated exchange of *knowledge* among clients decoupled in *space, time* and *reference*.



■ Triples and graphs

- Triples are ,linked‘ by having the same subject or object (state something about the same thing)
- Only graphs as a whole capture the information sufficiently (a graph can of course have one triple!)

■ Semantic matching

- The Linda language used associative addressing
- Triple Space retrieves matching tuples also based on the possible inference of new knowledge
 - e.g. find the name of one of Suzie’s pets can automatically infer that a cat or dog instance is a subclass of pet

out(Graph g, URI space,
URI ng)

A *graph* contains multiple triples (multi-write); triples are written to a particular space *s*, and might be grouped as a graph with the name *ng*.

Six retrieval operations, three read (rd, rda, rdg) and three in (in, ina, ing) with the same semantics but destructive.

rda(Template t, URI
space, int timeout)

Returns a graph containing **one** (a) matching triple and its bounded description.

Generalizes rda by returning an undetermined number of matching triples.

rd(Template t, URI
space, int timeout)

rdg(Template t, URI
space, int timeout)

Returns all triples belonging to the same graph that contains the matching triple.

- Publish / Subscribe mechanism
 - subscription for a given template in a given space
 - important for long-term coordination of services and applications

- Creation, destruction of space
 - installation of a new space
 - assignment of identifier
 - integration in space hierarchy (nested, hierarchical)
 - release of identifier binding and published data

- Matching the structure and meaning of triples, related triples and graphs
 - Triple patterns: **<suzie> info:hasPet ?o**
 - Graph patterns

TEMPLATE	DESCRIPTION
<code>?s a doap:Project; foaf:member ?o.</code>	Matches all triples where the subject is of type doap:Project and where the same subject has triples indicating the members.
<code>?s ?p ?o. ?o a foaf:Person.</code>	Matches all triples where the object is of type foaf:Person.
<code>?s foaf:name ?a; foaf:mbox ?b.</code>	Matches the triples that contain subjects for which the name and a mailbox (foaf:mbox) are indicated.

- RDF queries, e.g. SPARQL (W3C Working Draft, 03/07)
- Rules...



European Patient Summary (EPS):

- a **concise clinical document** of crucial citizen health data
- an enabling factor for an **European infrastructure for accessing and sharing** citizens' health data across Europe

Why Triple Space Computing and eHealth?

Decentralized and Distributed Shared Space

- Each healthcare party provides a node of the shared space

Persistent Publication of Information in the Space

- Healthcare parties persistently publish patient summaries in their own node, enforcing data ownership
- Other parties connected to the infrastructure can retrieve the published data
 - Decoupled in **time**, **location** and **reference**

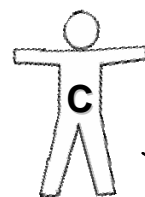
Coordination Support

- Enables multiple external applications to asynchronously and concurrently access the information, and
- Allows one party to trigger actions on other nodes

The Emergency Use Case Initialization of the Summary in UK



An English citizen asks his General Practitioner to **initialize** his **summary** in the EPS

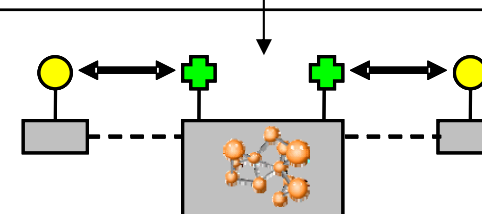


GP

Allergies (Morphine)
Immunizations (Tetanus)
Diseases (Calcium Deficiency)
...

The GP publishes the citizen's clinical information into the EPS through the **electronic Health Record**

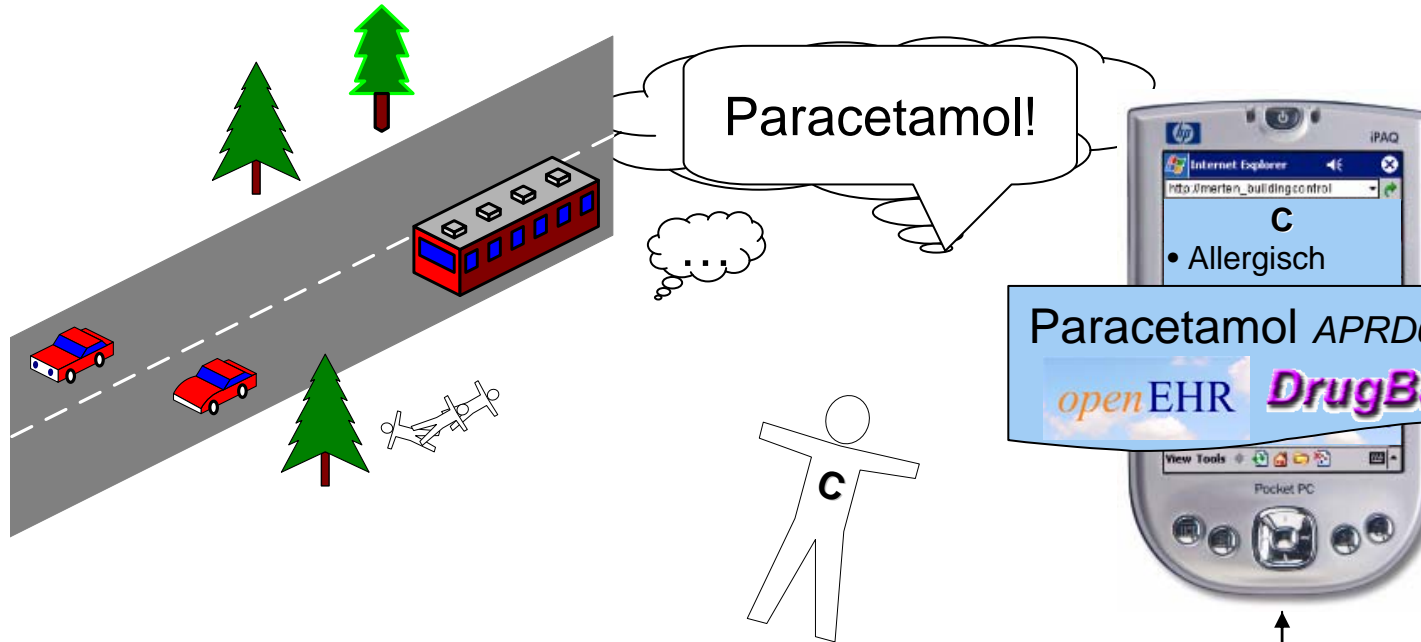
Allergy to Morphine *UMLS C0026459*
Immunization to Tetanus *Medline Plus 615*
Calcium Deficiency *UMLS C0020598*



C = Citizen

GP = General Practitioner

The Emergency Use Case The Incident in South Tyrol



Medical benefits

- Language understanding
- Privacy compliance
- Avoidance of administering a wrong drug

TS capabilities

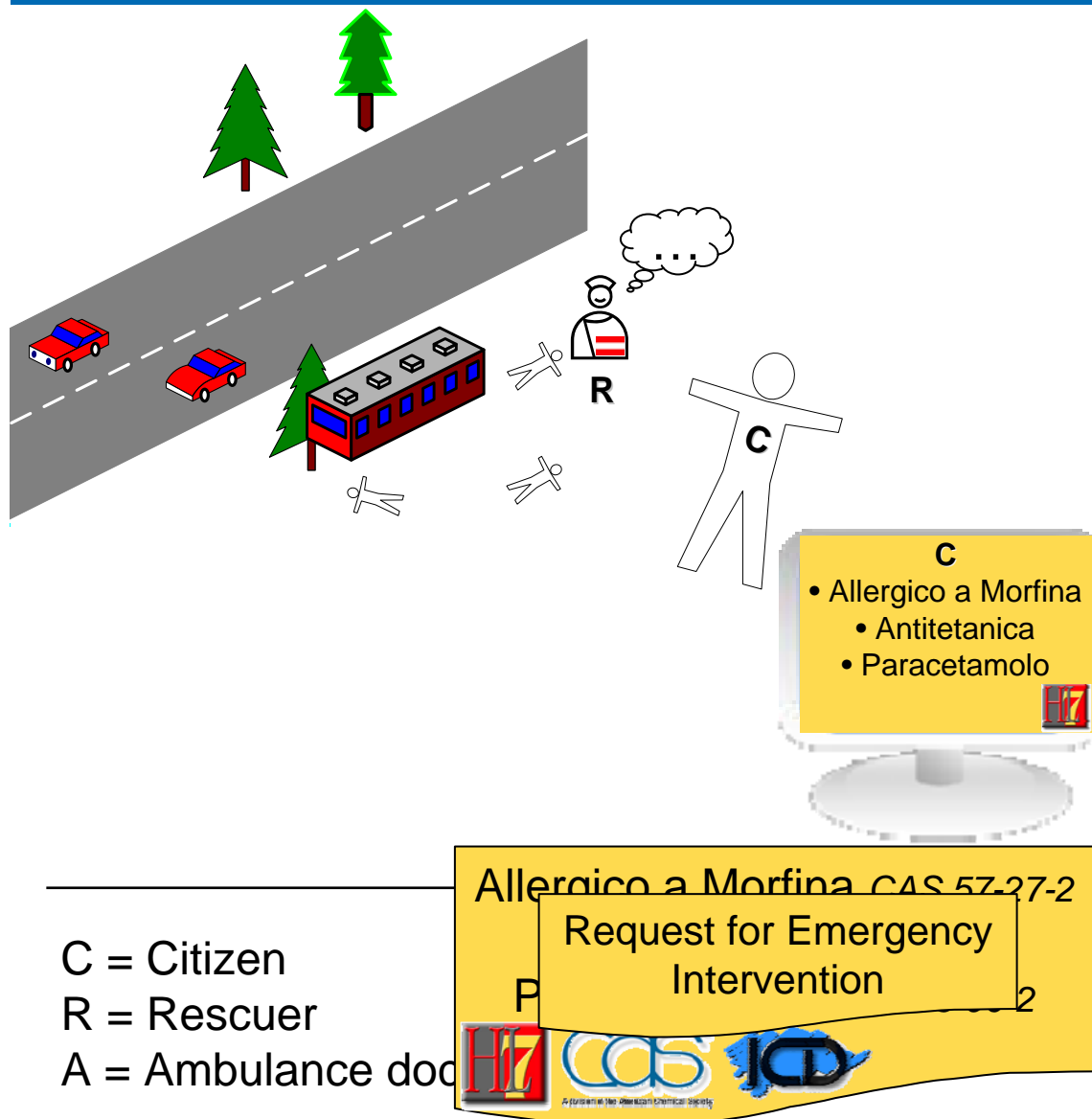
- **Decoupling** interaction in Time, Location, Reference and Schema
- Data and Application **interoperability**
- **Security**

C = Citizen
R = Rescuer

Allergisch gegen Morphinum APRD00215

openEHR SNOMED INTERNATIONAL

The Emergency Use Case Ambulance Coordination



C = Citizen
R = Rescuer
A = Ambulance doc

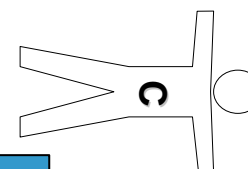
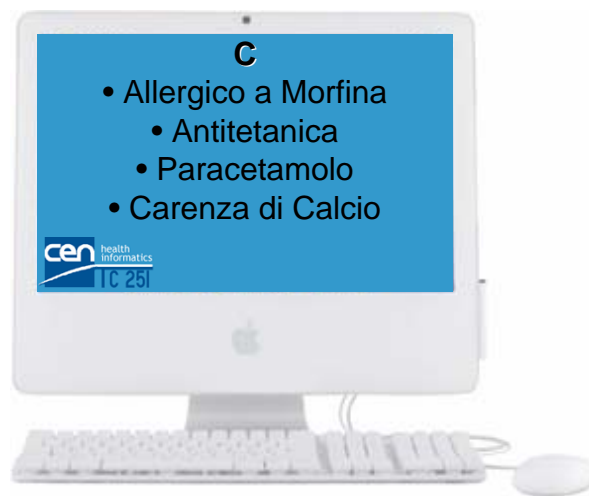
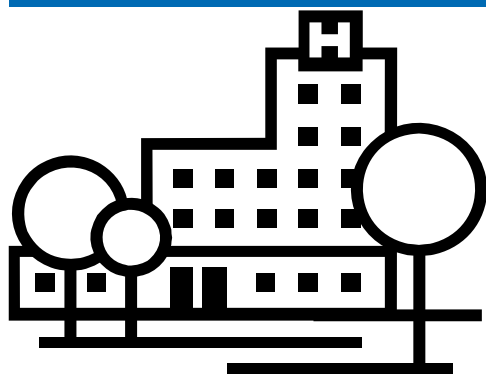
Medical benefits

- Awareness of current clinical situation
- Support for interactions

TS capabilities

- **Asynchronous messaging** to coordinate concurrent and heterogeneous applications

The Emergency Use Case Hospital Coordination



Allergico a Morfina CAS 57-27-2
 Antitetanica ICD Y58.4
 Paracetamolo CAS 103-90-2
 Carenza di Calcio ICD E58

C = Citizen
 A = Ambulance doctor
 E = Emergency doctor



Medical benefits

- Awareness of patient clinical situation
- Foresee acceptance for a more efficient treatment

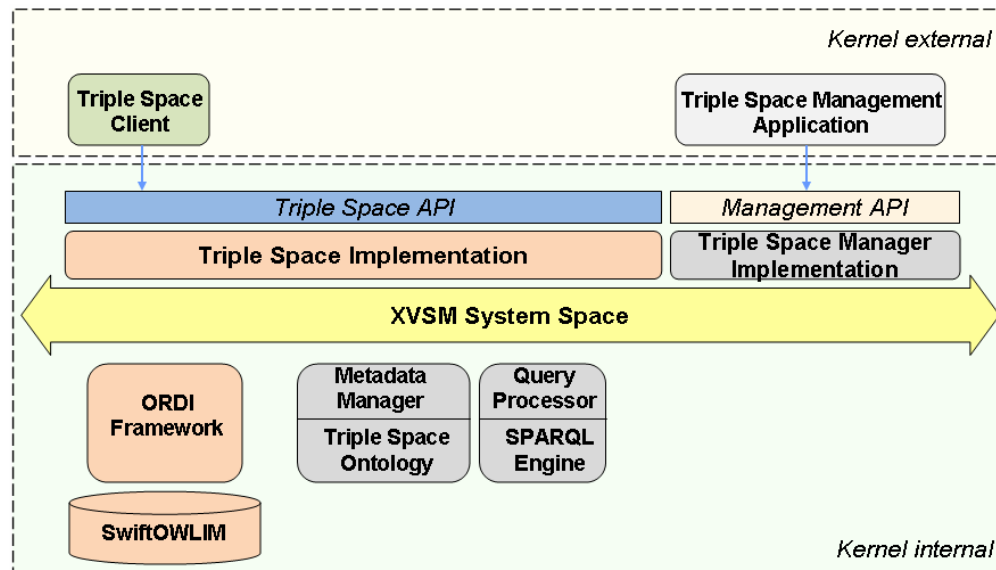
TS capabilities

- **Publish and Subscribe** mechanisms to coordinate concurrent and heterogeneous applications

Conclusion

- Triple Space Computing enables
 - **asynchronous, reliable and meaningful communication**
 - **interoperability and coordination** of multiple heterogeneous actors
- This is demonstrated and validated in an eHealth scenario: European Patient Summaries

- There is a first prototype available
 - Single node solution
 - Coordination API support
 - Modeling of spaces and graphs
 - Query Engine for triple pattern and SPARQL templates



- Next release
 - Integration of Triple Space ontology
 - Distribution of space and data
 - Multi-kernel space implementation

- Distribution/scalability as major challenge/focus
 - Multiple, distributed Triple Space kernels
 - Partitioning, replication, clustering of RDF triples
 - Distributed template/query resolution

Thank you, any questions?