A reference model and a theory for multiagent, information systems

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Outline

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A Theory for Systems.

A multi-agent theory for information system

- A theory of systems
- A mathematical theory for system simulation
- A mathematical theory for multi-agent systems
- A mathematical theory for multi-agent, information systems (and services)

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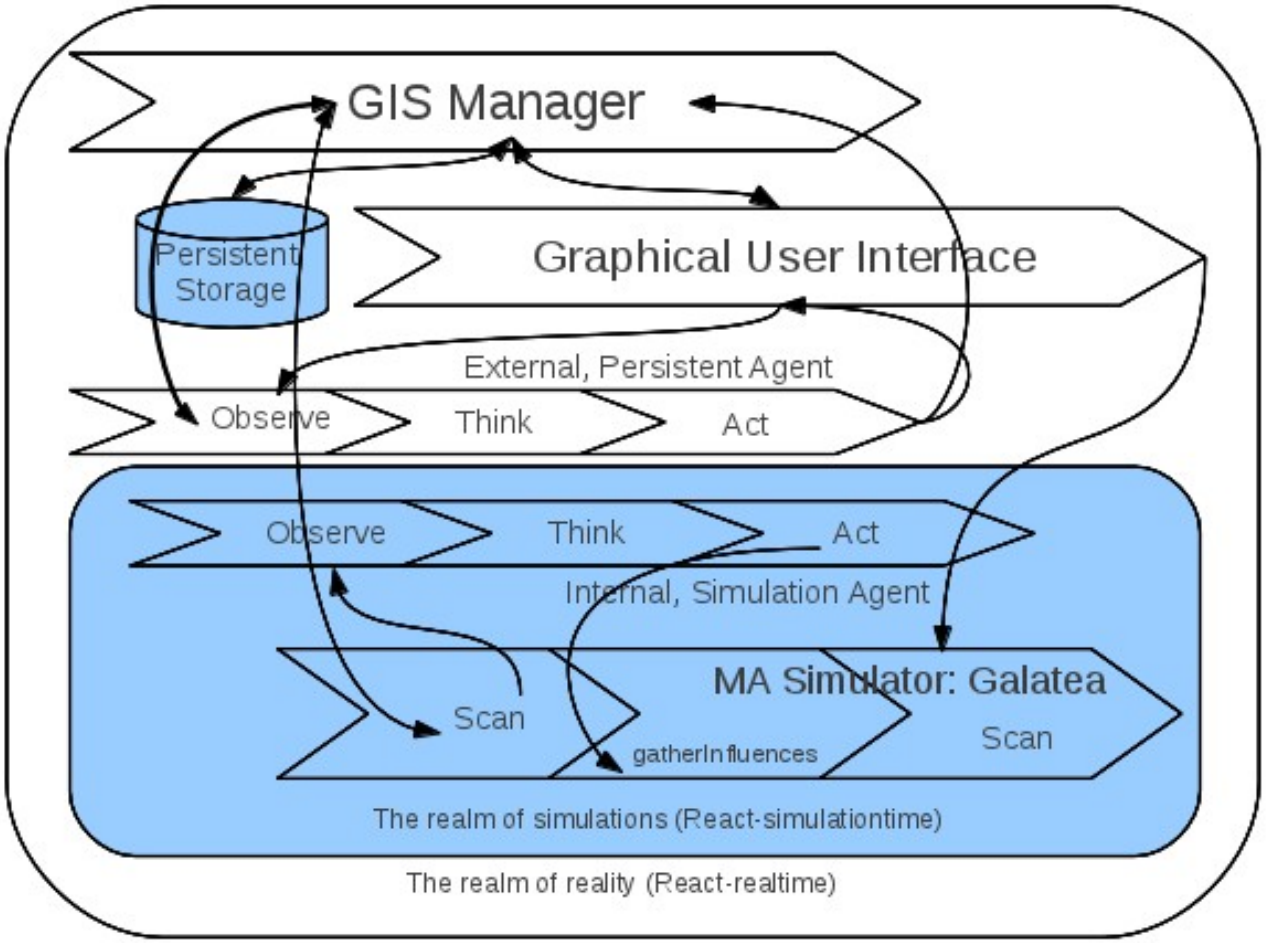
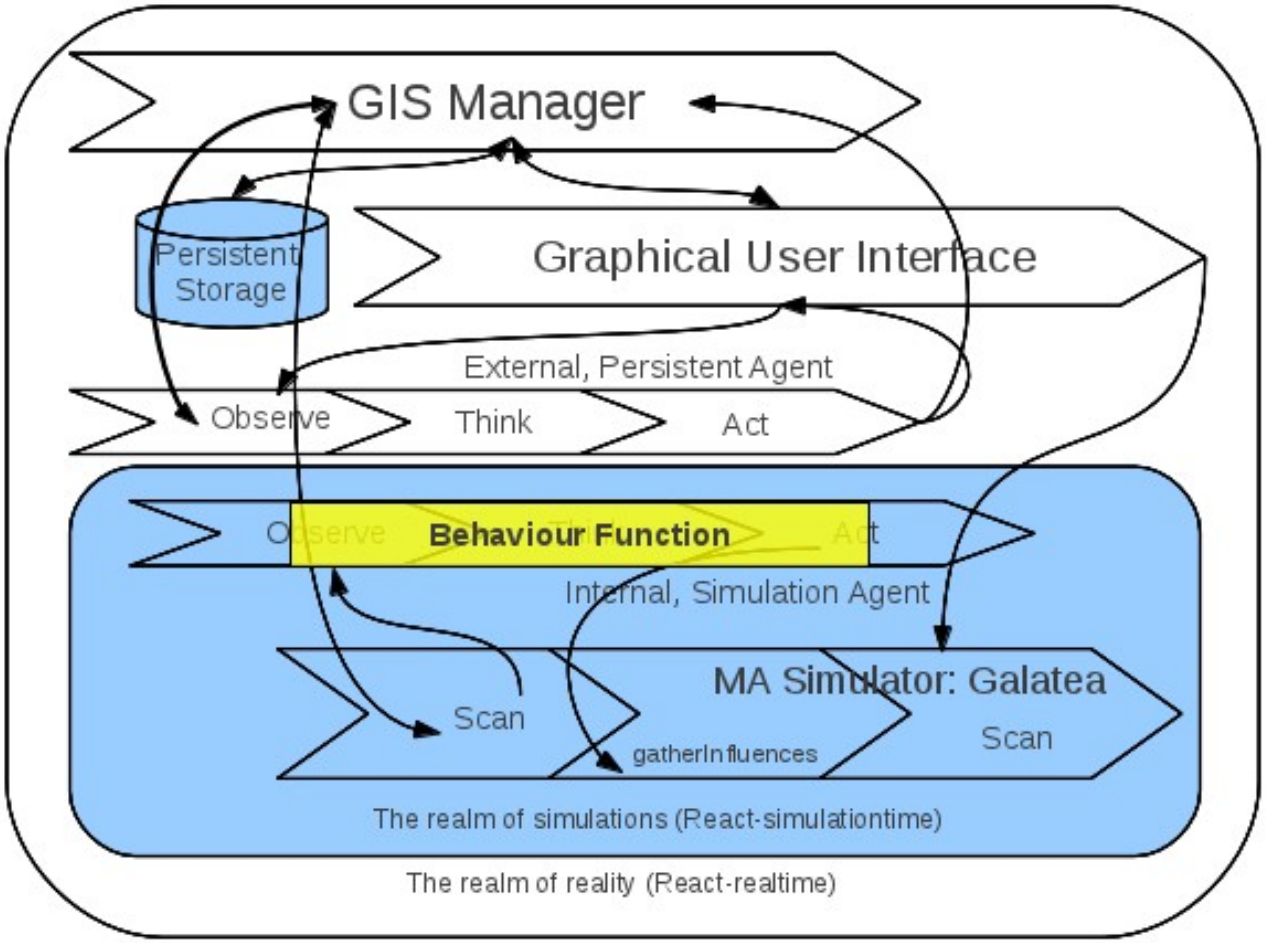
Processes of the Service



Currently Implemented (in GALATEA)



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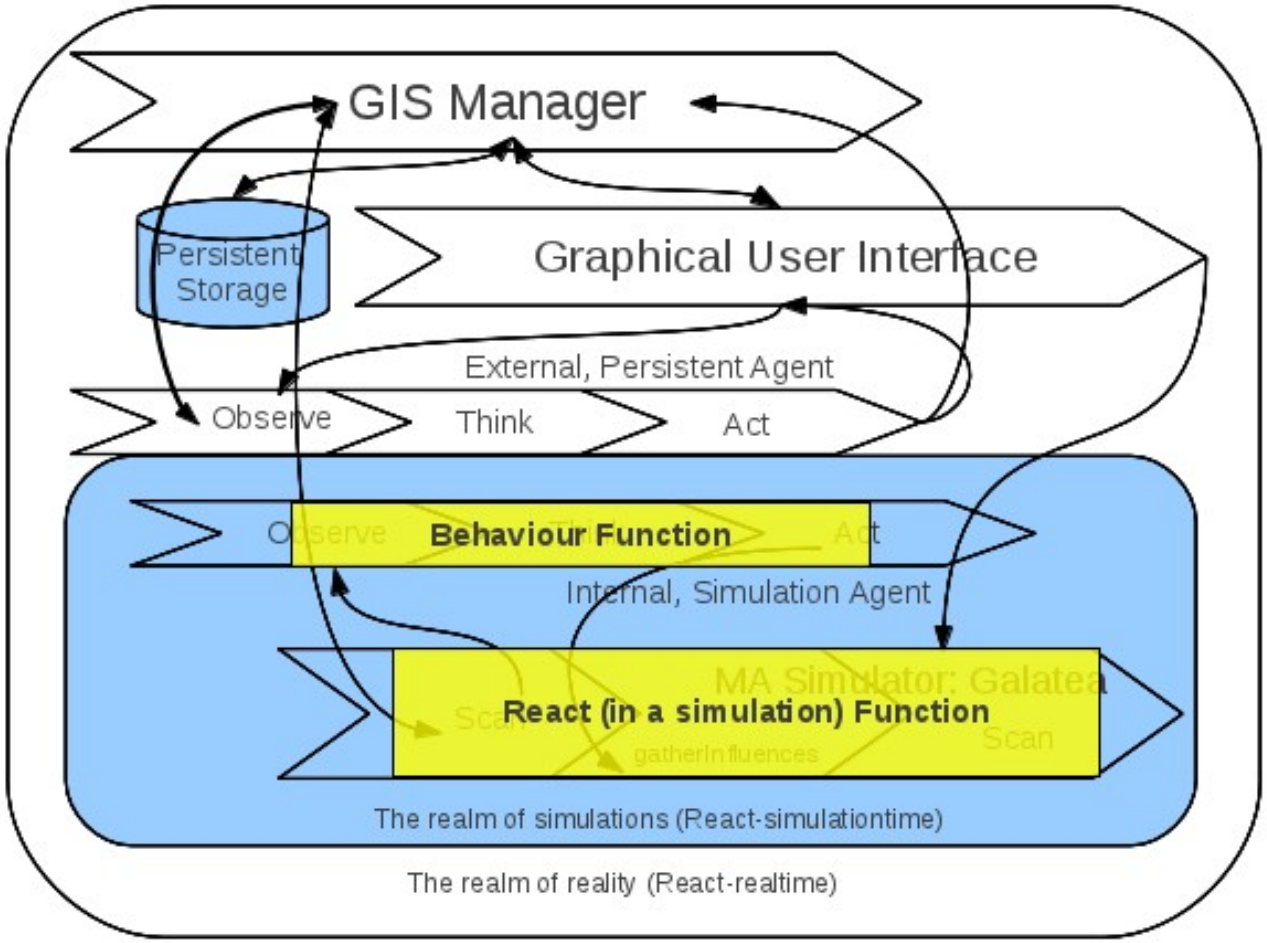
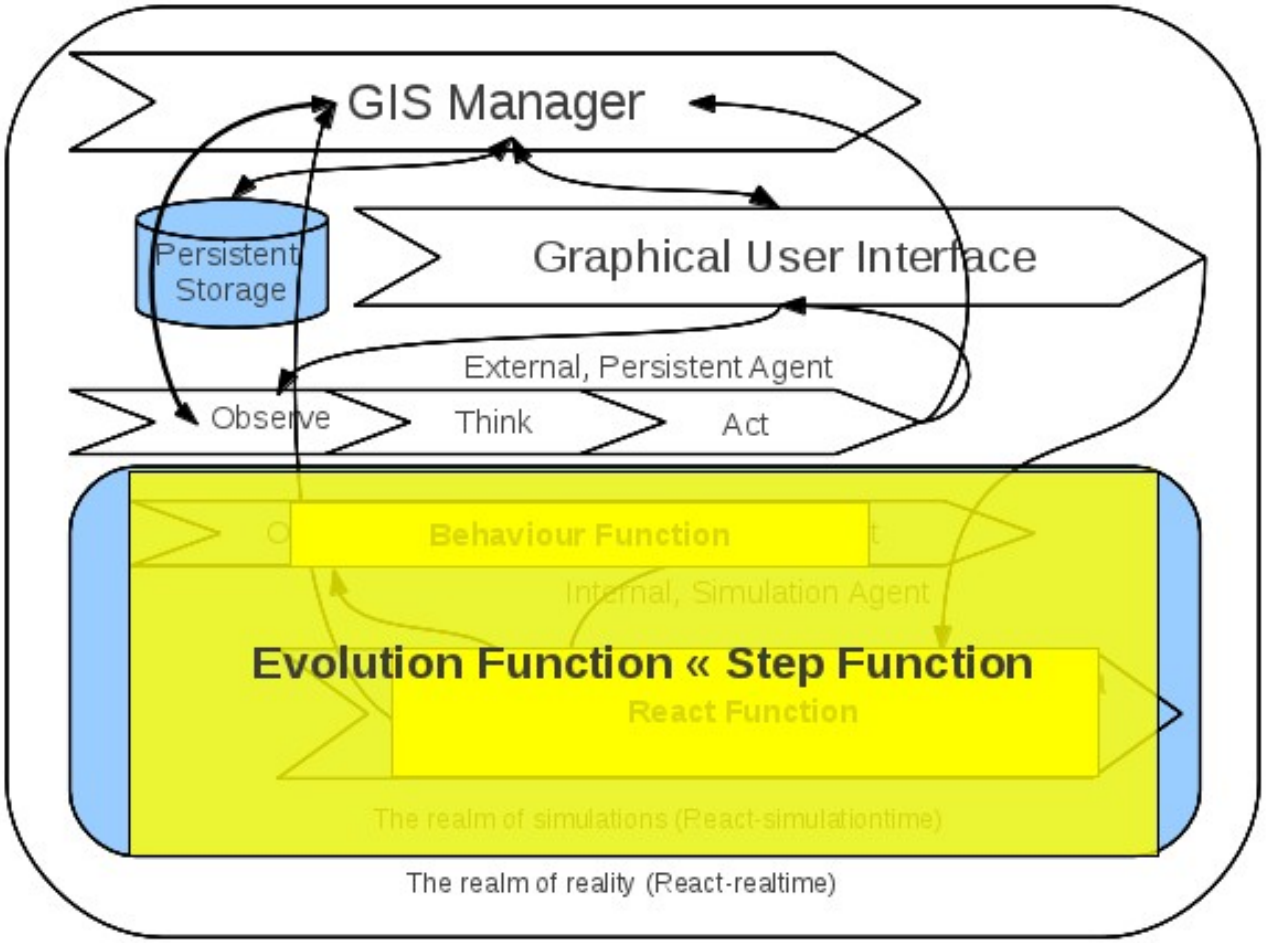
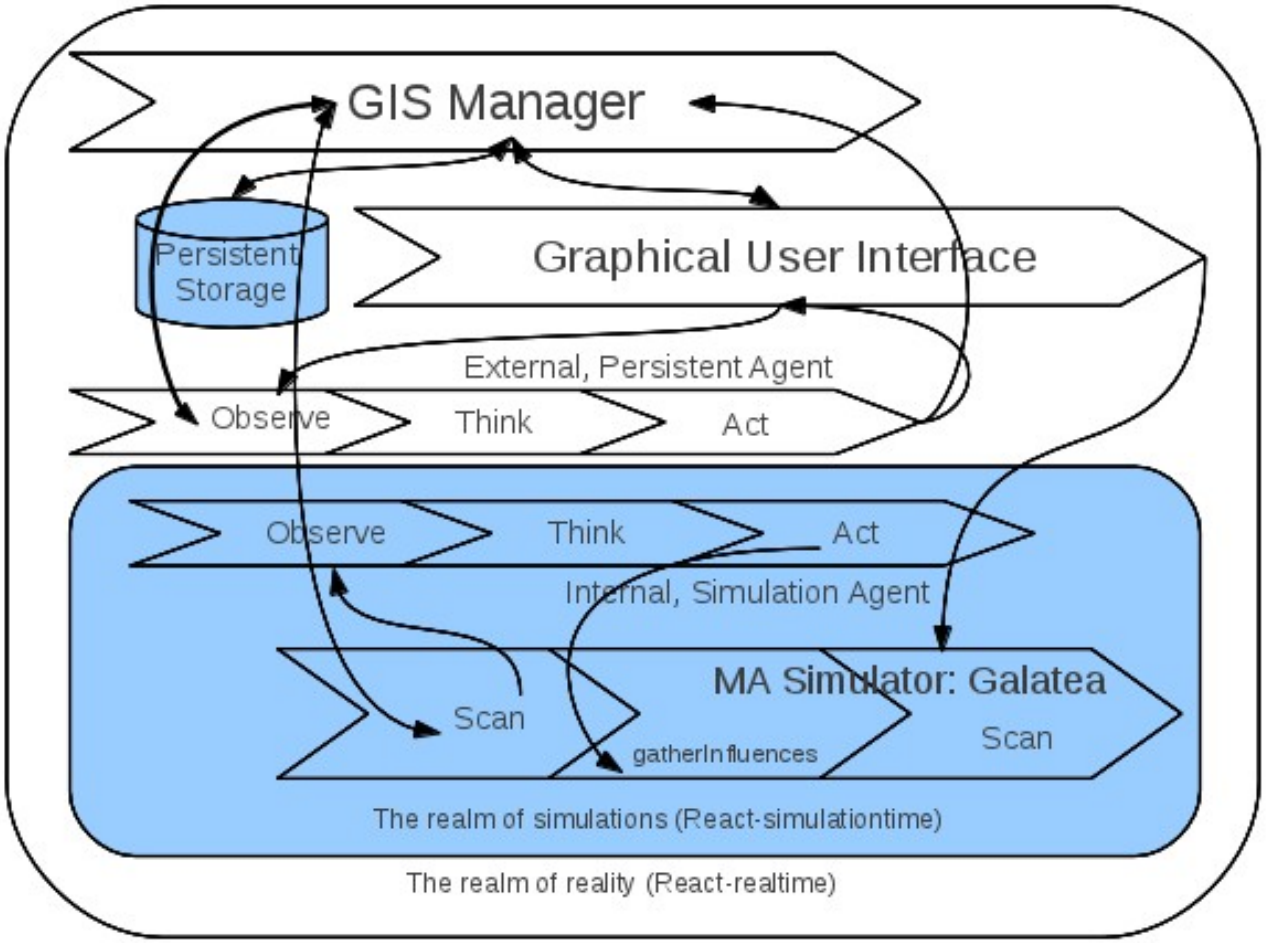


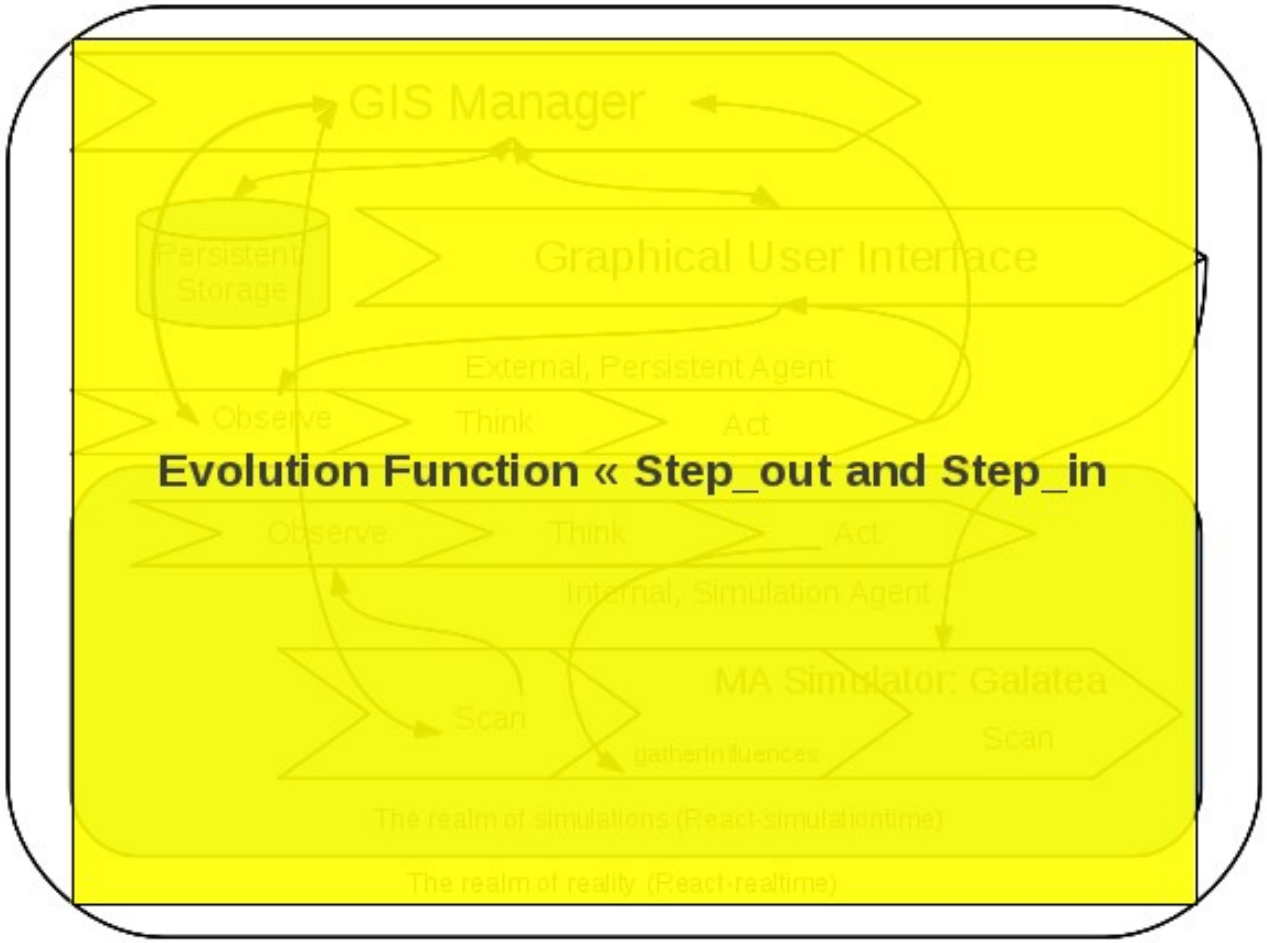
GALATEA's original theory cover this



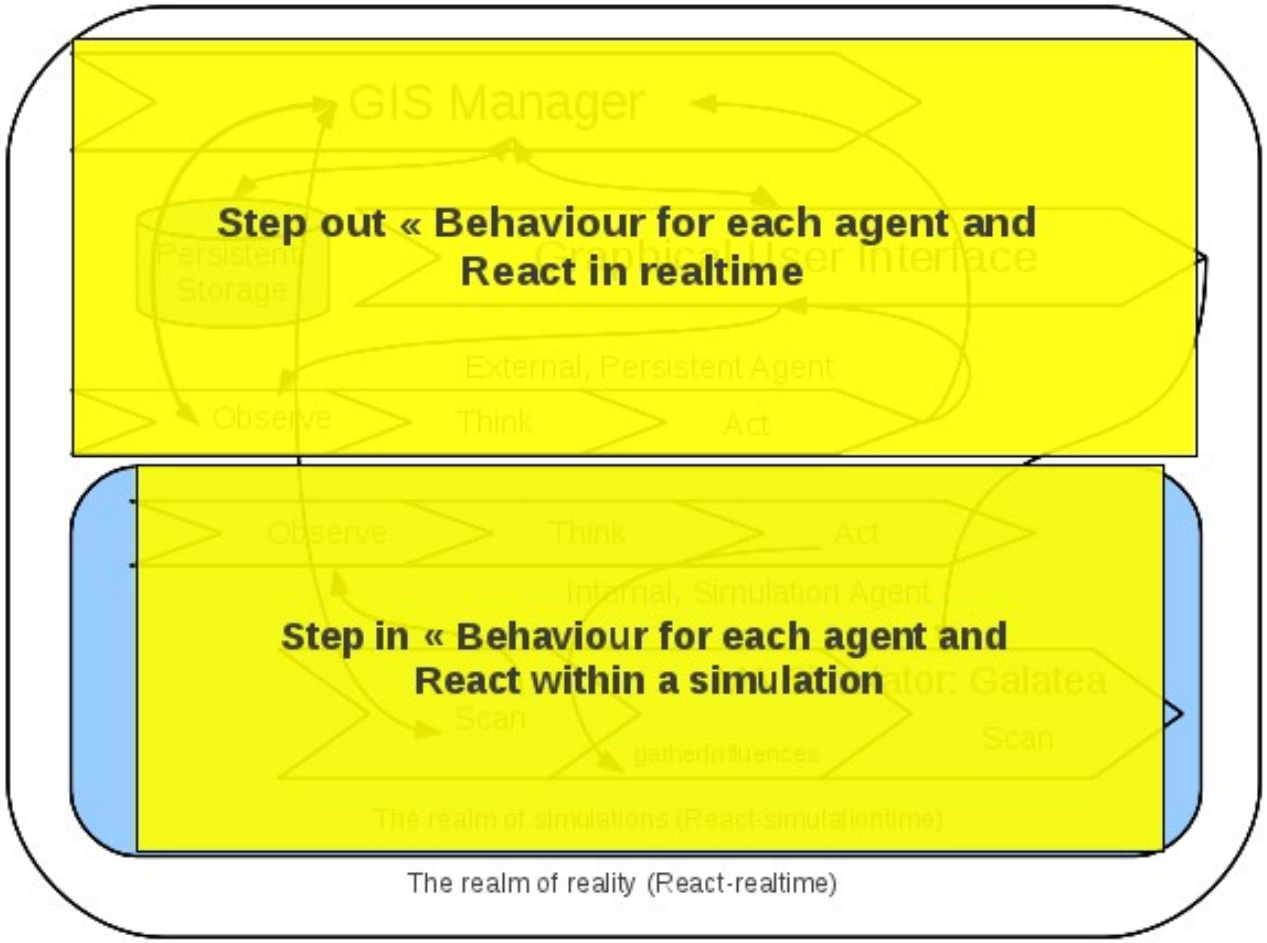
Now we go for more



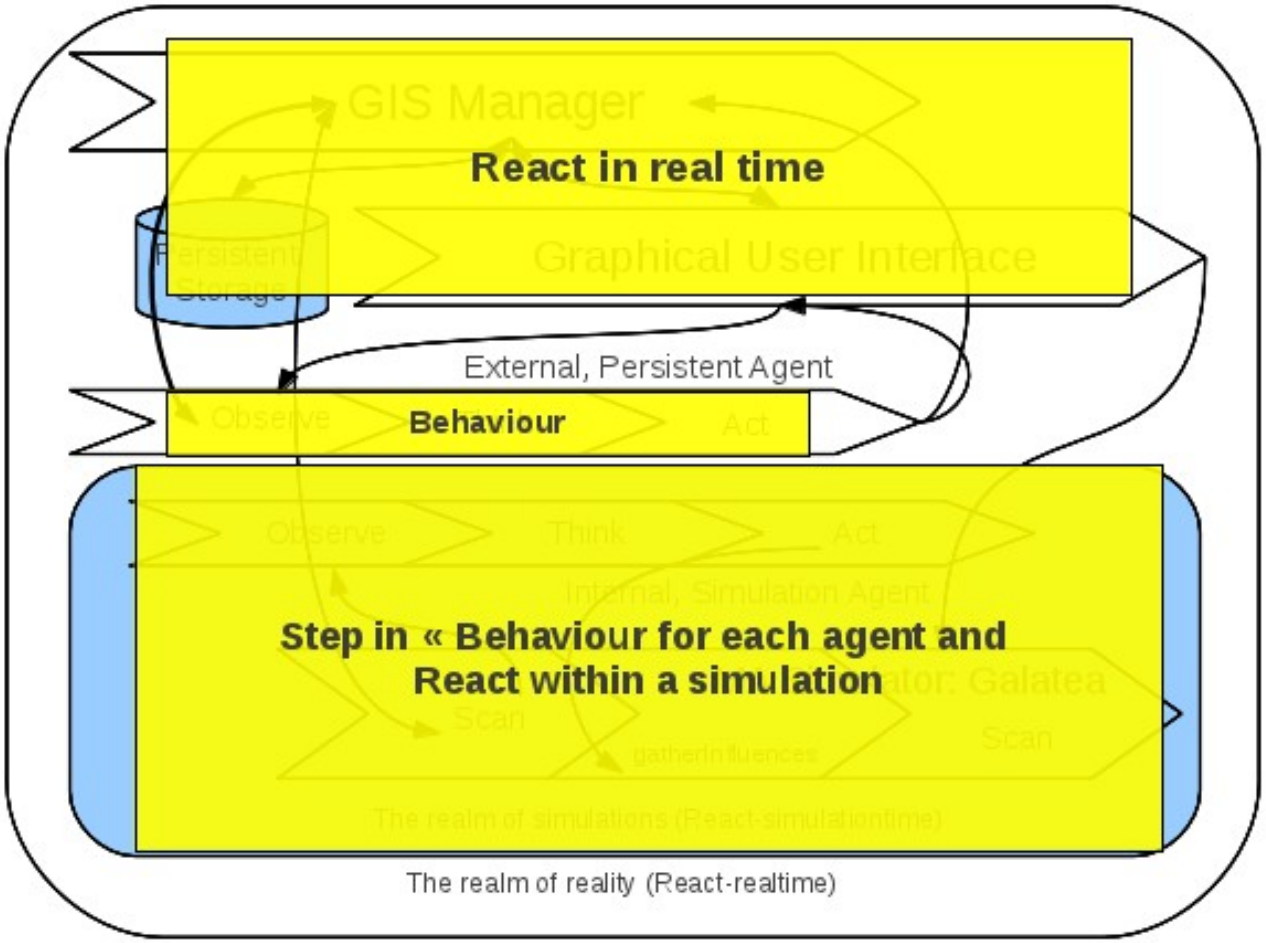
A whole information service



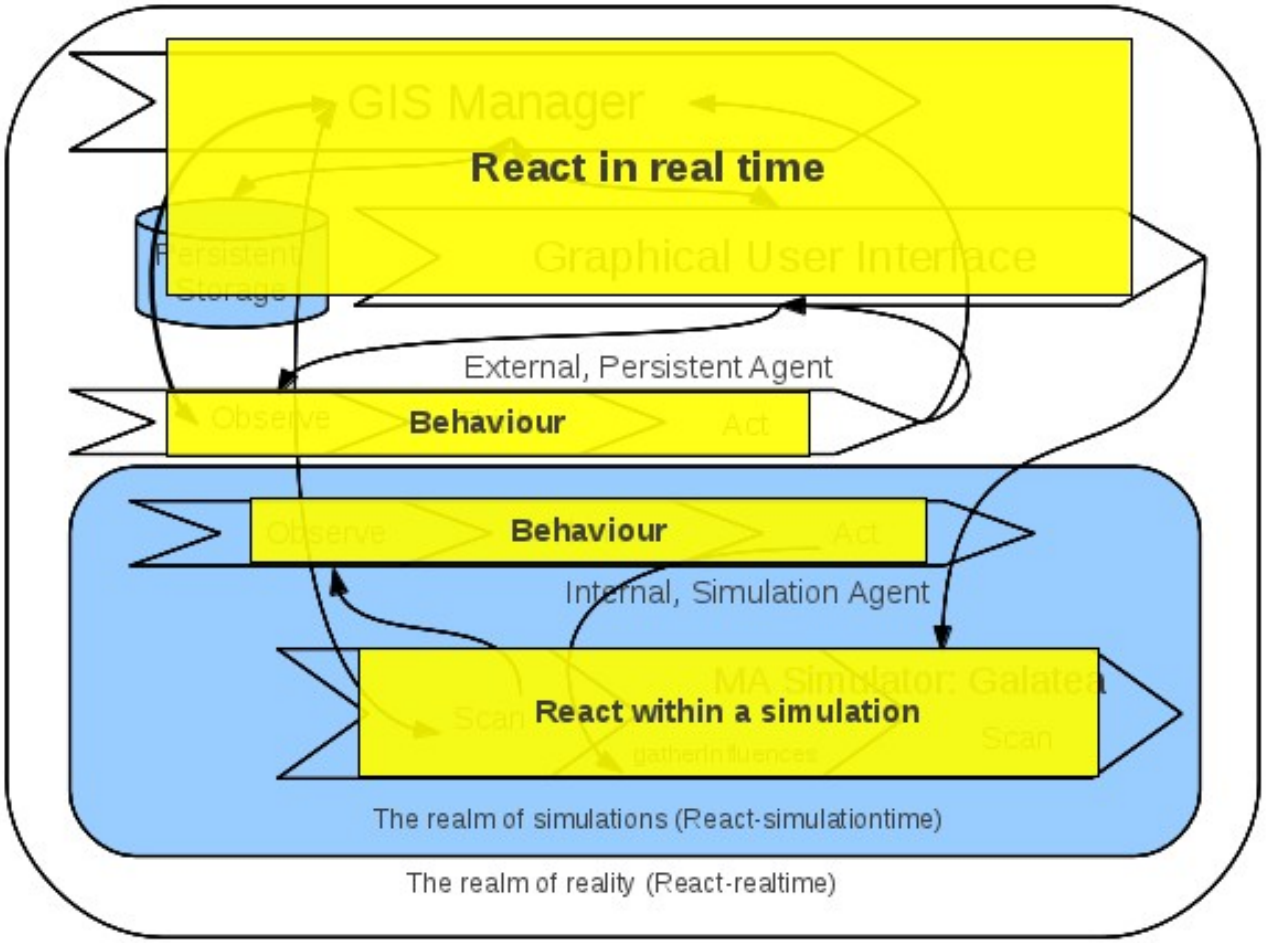
The two realms



Reusing previous processes



Integrating them all



Outline

A formal model of a MultiAgent System

$$Evolution : \Im \otimes Env^* \rightarrow \varepsilon$$

$$Evolution(t, env) = Evolution(Step_{out}(t, env)) \quad (1)$$

$$env \in Env^*$$

$$Env^* =< P_G, F_G, \mathscr{L}, \Gamma > \quad (2)$$

A forma model of a MultiAgent System

where P_G represents the set of all possible global *parameter=value* pairs and F_G the set of all possible global functions operating upon those parameters, while$\mathscr{L}$ is the set of all possible layers of objects that may constitute the geography of the system. Each layer, $L \in \mathscr{L}$, in turn is defined by 3-the tuple:

$$L =< P_L, F_L, \mathscr{A} >$$

where P_L and F_L are the local counterparts of P_G and F_G, and$\mathscr{A}$ represents the set of entities (objects and agents) that populate the system.

Step Out

$Step_{out} : \Im \otimes Env^* \rightarrow \Im \otimes Env^*$:

$$< t'', env'' >= Step_{out}(t, env) \quad (3)$$

where $env'' =< p'', f, l'', \gamma'' >$
and $env =< p, f, l, \gamma >$,
and $p'' \in P_G$, $f \in F_G$, $l'' \in \mathscr{L}$, $\gamma'' \in \Gamma$.
Remember: each layer l is described by $l =< p_l, f_l, A >$ where A is the set of agents in this layer.

The Environment Reacts

$$< p'', f, l'' >= React_{realtime}(t', p', f, l', \gamma') \quad (4)$$

$$< \gamma'' >= Exec(p', f, l', \gamma' \cup_i \gamma'_i) \quad (5)$$

where $\gamma' \cup_i \gamma'_i$ is the union of the previous history and the set of influences from all the agents at time t'.

The Behaviour of each Agent in the "Real Environment"

$$< s_i'', \gamma_i' >= Behaviour_i(t', r_i, s_i', \gamma) \quad (6)$$

But, let us "step in(to" a simulation)

$Step_{in} : S \otimes \Im \otimes Env^* \otimes \Gamma \rightarrow S \otimes \Im \otimes Env^* \otimes \Gamma$:

$$Step_{in}(< s_1, s_2, .., s_n >, t, < p, f, l >, \gamma) = << s'_1, s'_2, .., s'_n >, t', < p', f, l' >, \gamma' > \quad (7)$$

The Simulated Environment also reacts

$$React_{simulationtime} : \Lambda \otimes \beta \otimes \Im \otimes Env^* \otimes \Gamma:$$

$$\begin{aligned} &<< p', f, l' >, \gamma' > \\ &\quad = \quad React_{simulationtime}(\\ &\qquad <\lambda_1 || ... || \lambda_m>, \\ &\qquad t, \\ &\qquad < p, f, l >, \\ &\qquad \gamma \cup_j \gamma_j) \end{aligned} \tag{8}$$

the agents "inside" simulations

$$< s'_j, \gamma_j >= Behaviour_j(t, r_j, s'_j, \gamma) \quad (9)$$

$$\xi = NextEvent(\gamma \cup_j \gamma_j) \quad (10)$$

$$< p, f, l >= Scan^*(env, \xi) \quad (11)$$

$$t' = TimeOf(\xi, t) \quad (12)$$

but.. What is an Agent?

An agent is a 4-tuple:

$$a_\tau =< k, goals, georefs, Context > \tag{13}$$

Notice that, as indicated by the subscript, this agent is associated to a agent type τ which, in turn, is formalized by the 8-tuple:

$$\tau =< K_\tau, G_\tau, Shapes_\tau, \sum_\tau, P_\tau, Perception_\tau, Update_\tau, Planning_\tau > \tag{14}$$

An Agent described as the Behaviour function

$$Behaviour_a : \Im \otimes \Re \otimes K_\tau \otimes G_\tau \otimes \Gamma \rightarrow K_\tau \otimes G_\tau \otimes \Gamma$$

$$< k', goals', \gamma_a >= Behaviour_a(t, r_a, k, goals, \gamma) \quad (15)$$

where

$$k' = Update_a(t, Perception_a(\gamma), k)$$

$$< \gamma_a, goals' >= Planning_a(t, r_a, k', goals)$$

and where $< k', goals', \gamma_a >$, depicts the knowledge base, the goals of agent a and the influences, γ_a, this agent is posting to its environment as actions it intends to execute.

Summary

- We have developed a mathematical theory for multi-agent, information systems
- We have use it to guide the implementation of a MA Simulation Platform (GALATEA).
- We want to use it to guide the implementation and deployment of simulation and GIS services

For Further Reading I

- Bernard P. Zeigler. *Theory of modelling and simulation.* Interscience. Jhon Wiley and Sons, New York, 1976.
- Jacques Ferber and Jean-Pierre Müller. *Influences and reaction: a model of situated multiagent systems*. In ICMAS-96, pages 72–79, 1996.
- I. Blecic, A. Cecchini, and G. Trunfio. *Studies in Computational Intelligence*. Volume 176, chapter A Multi-Agent Geosimulation Infrastructure for Planning, pages 237-253. Springer, Berlin, 2009.
- J. Dávila, M. Uzcátegui, and K. Tucci. *From a multi-agent simulation theory to galatea*. In Summer Computer Simulation Conference (SCSC0'7), San Diego, CA, USA, 2007.

For Further Reading II

- V. Padilla, J. Dávila. *A reference model and a theory for multiagent, information systems*. LPAR-18, Mérida, Venezuela. 2012.
- Fahad A. Shiginah and Bernard P. Zeigler, *A new cell space DEVS specification: Reviewing the parallel DEVS formalism seeking fast cell space simulations*, Simulation Modelling Practice and Theory,2011
- B.P. Zeigler, H. Praehofer, and T. Gon Kim. *Theory of Modelling and Simulation*. Academic Press, San Diego, second edition, 2000.