The Challenge of Complexity in the Design of e-Business Support Software.

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President WIN s.a.

PURPOSE OF THE PAPER.

To present the contribution of Life Sciences to the design of complex e-Business Information Systems.

- **Complex Business Systems are those for which there are no logical models able to anticipate there answers to solicitations.**
- **The only approach to design is then empiricism and intuition, i.e. to work by analogy. This is often misleading for new contexts.**
- **Life sciences has contribute a lot to a new and better understanding of the logical modeling of complex systems.**

An EXAMPLE : e-Gov SYSTEMS.

Complexity of such projects

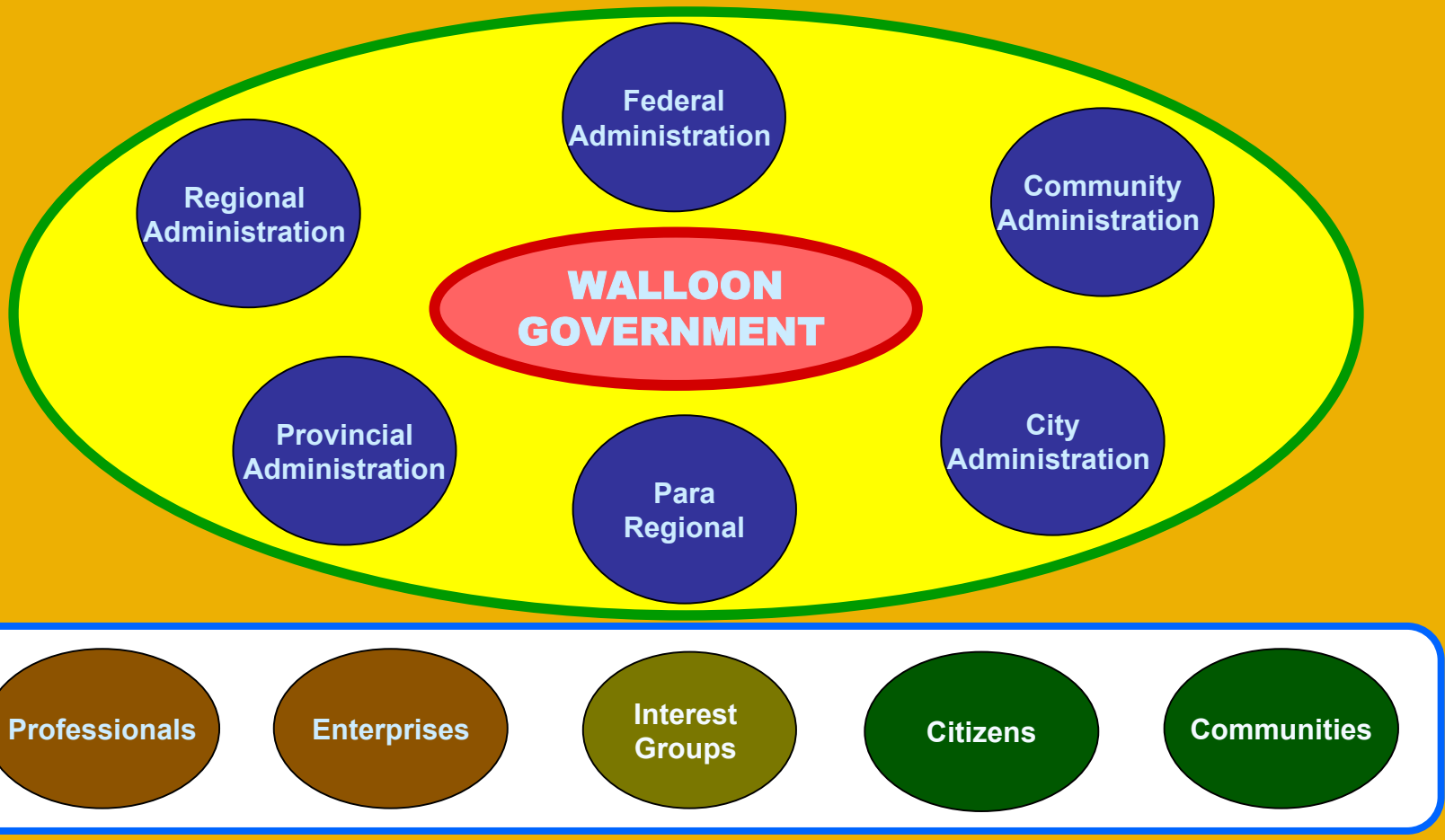
- **Very high numbers of stakeholders:**

  millions of users, hundred thousands of information 's suppliers, thousands of controllers and regulators involved,

- **Heterogeneity of existing processes,**
- **Level of service quality expected,**
- **Large extent of legal problems,**
- **Many numbers of new types of jobs.**

NEVER BEFORE HAS THE WALLOON REGION UNDERTAKEN SUCH A COMPLEX PROJECT.

ACTORS IN AN e-Gov SYSTEM.



e-GOV SERVICES PORTFOLIO

I. APPLICATION SERVICES :

a. Access Portal and Common Entities Identifications,
b. Citizens Applications,
c. Moral Persons Applications,
d. Administration Applications,
e. International e-Gov Applications

II. SUPPORT SERVICES :

a. Call Center for User's Accreditation,
b. Contention Management,
c. Hot Line for Inquiries, Suggestions and Complaints,
d. Education Center for Professional Users,
e. Promotion Center for News, Diffusion of New Services,
f. Billing services,

III. AUXILIARY SERVICES :

a. Printing services,
b. Work Flow and Agenda Management,
c. Recovery of Interrupted Transactions,
d. Encrypting and Identity Certification,
e. Automatic Validation and Completion of Public Entities,
f. Automatic Calls of Services by Private Applications Programs,
g. E-Learning services for Government `s staff.

CRITICAL QUALITY OF AN e-Gov.

I. USER'S CONVIVIALITY:

- Response time, even under heavy load,
- Common Look and Feel,
- Common Command Language,
- Automatic Suggestion of Known Data,
- Interaction Guidance of Users,
- Personalized services,
- Integration of clusters of services,
- Best Practices description,;

CRITICAL QUALITY OF AN e-Gov.

II. PROTECTION AGAINST DEFAULTS AND AGGRESSION:

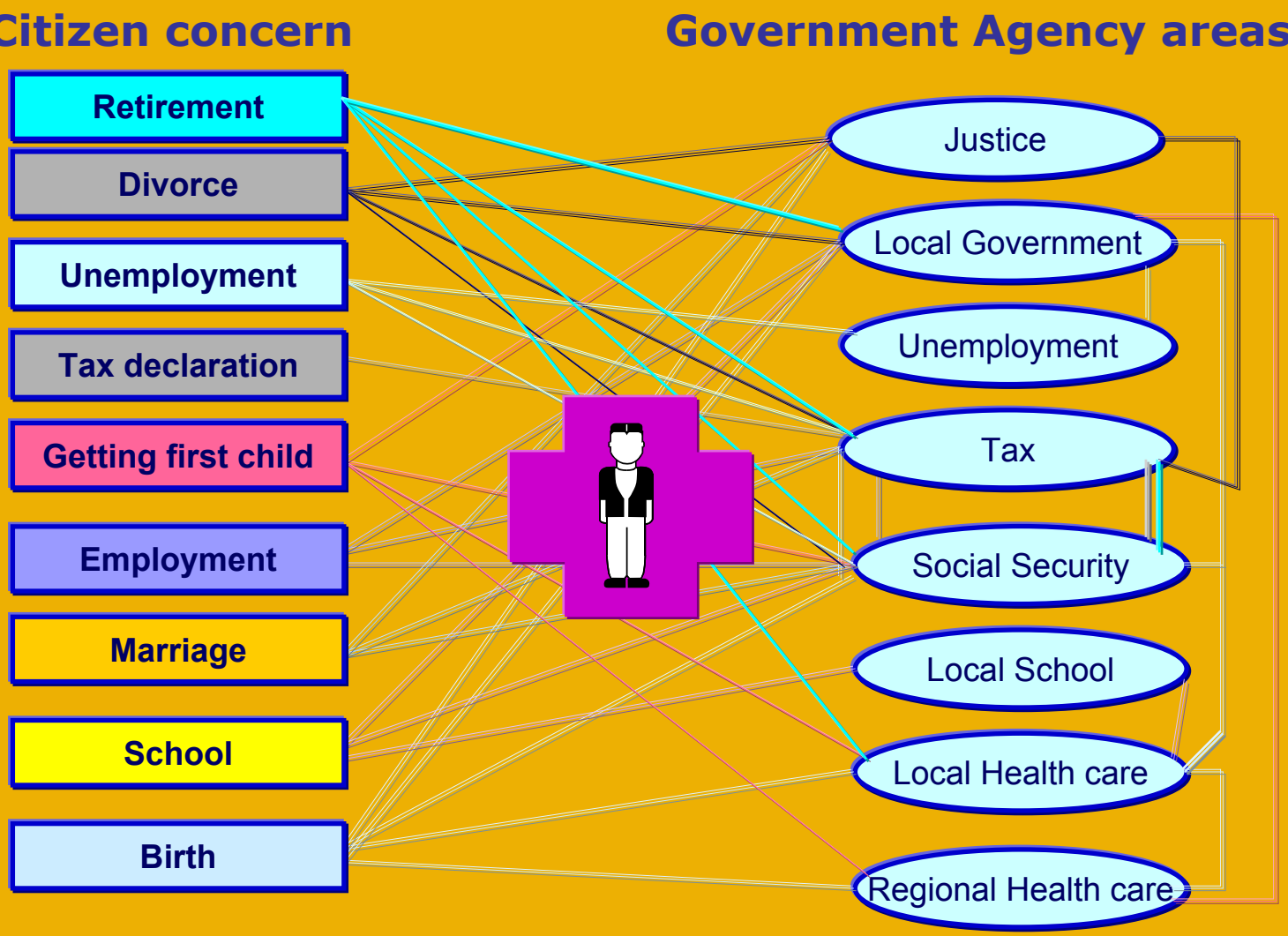
- Confidentiality i.e. protection against unauthorized access to data exchanged between users and the e-Gov system,
- Security of service, i.e. authenticity of the people emitting messages in a process,
- Reliability of service, i.e. adequacy and accuracy of delivered information's,
- Legality of procedures, i.e. conformity of the services to the law in force,

CRITICAL QUALITY OF AN e-Gov.

III. FLEXIBILITY OF THE SYSTEM :

- Large scope of accepted terminals: Telephones, PC, TV, Notepad, GSM, SMS,
- Different terminals for disable people,
- Services unaffected by volumes of users,
- Changeable rules for procedures according to the evolution of the legislation,
- Different procedure's scenarios depending of the experience of the user,
- Default values proposed as function of user's,

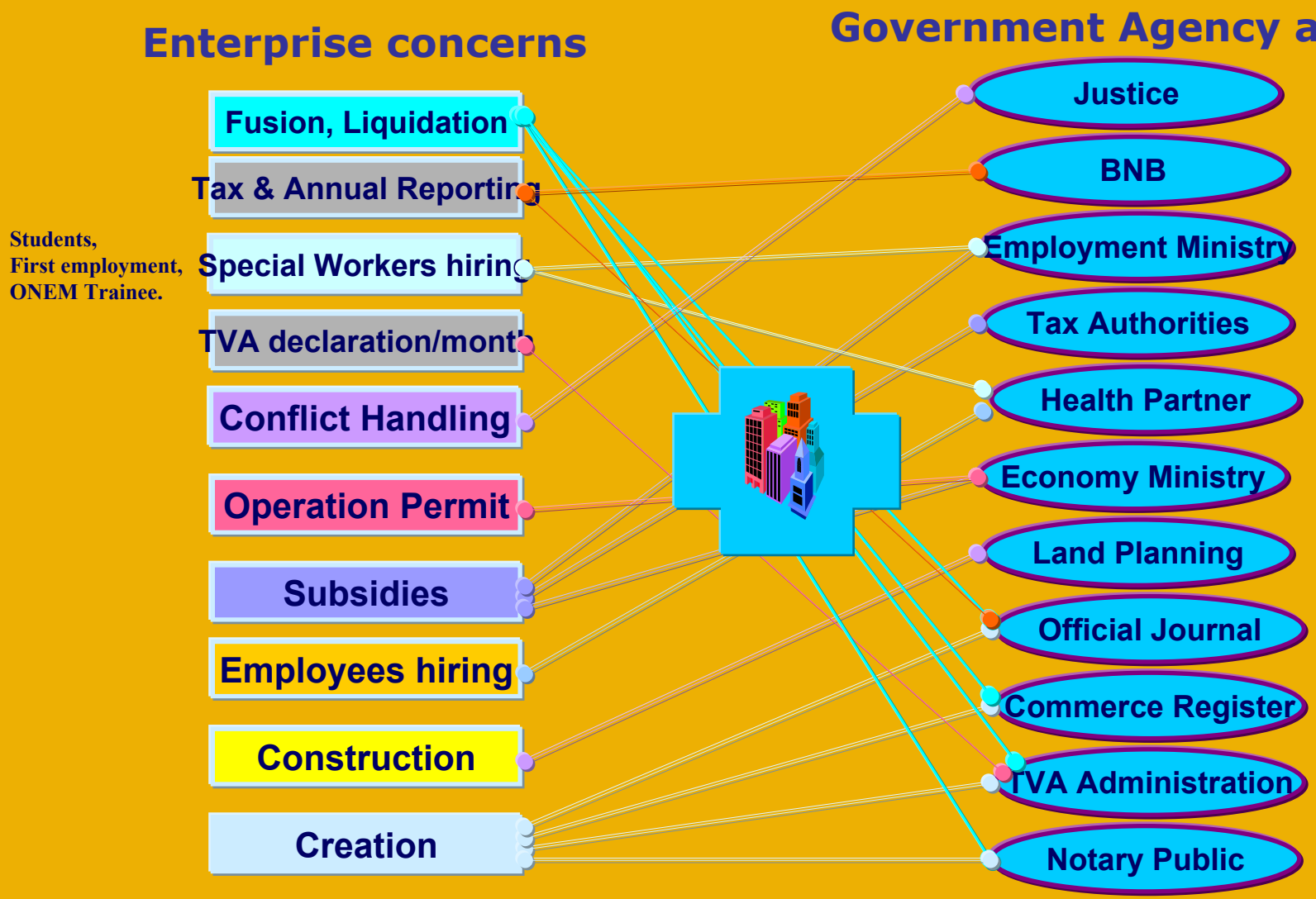
THE CITIZEN LIFE EVENT PROCESS



PUBLIC SERVICES FOR CITIZENS

1. Income taxes: declaration, notification of assessment
2. Job search services by labor offices
3. Social security contributions : Unemployment benefits, Child allowances, Medical costs (reimbursement or direct settlement), Student grants
4. Personal documents (passport and driver's license)
5. Car registration (new, used and imported cars)
6. Application for building permission
7. Declaration to the police
8. Public libraries (availability of catalogues, search tools)
9. Certificates (birth and marriage): request and delivery
10. Enrolment in higher education / university
11. Announcement of moving (change of address)
12. Health related services (interactive advice on the availability of services in different hospitals; appointments for hospitals)

THE ENTERPRISE LIFE EVENT PROCESS



PUBLIC SERVICES FOR BUSINESS

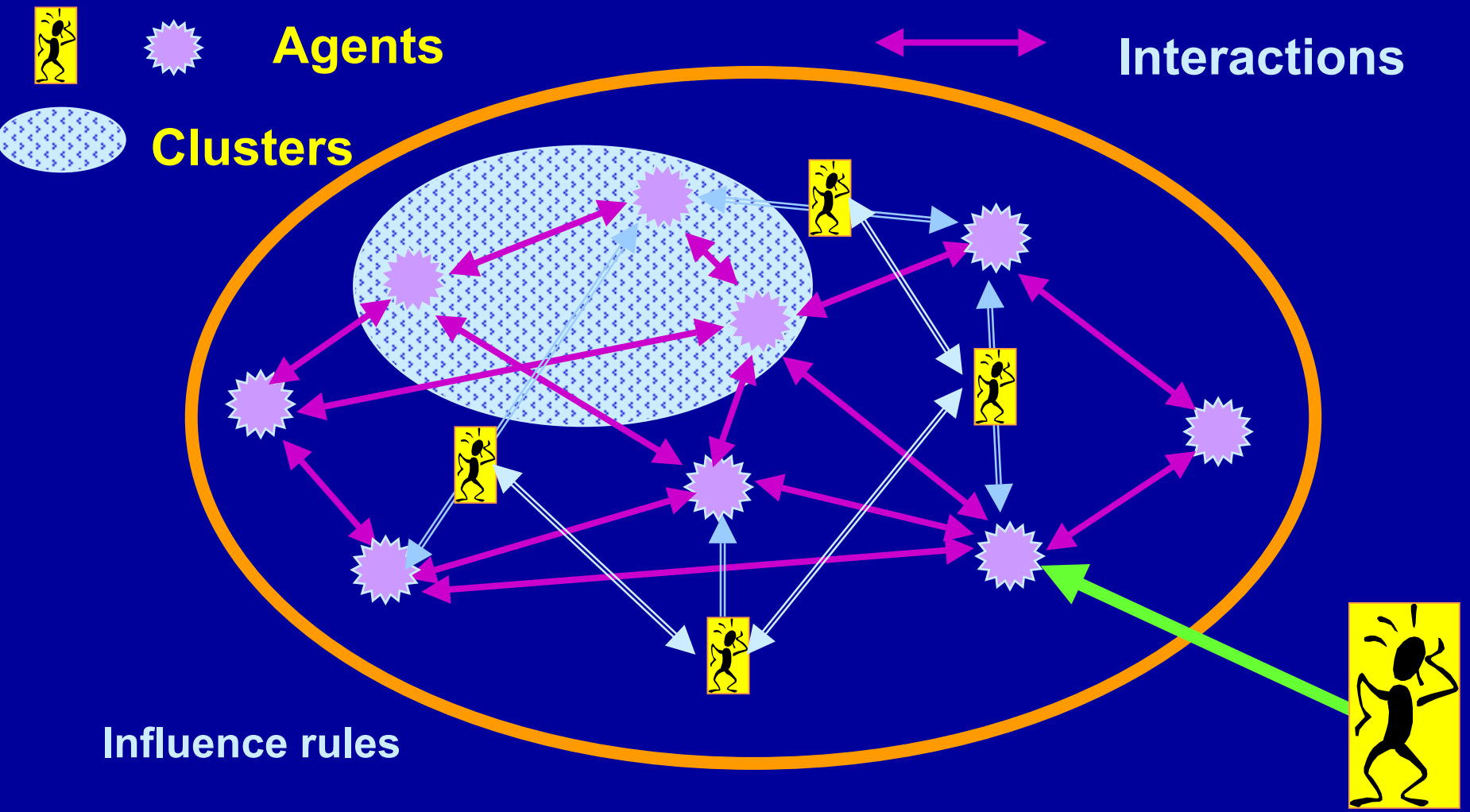
1. Social contribution for employees
2. Corporation tax: declaration, notification
3. VAT: declaration, notification
4. Registration of a new company
5. Submission of data to statistical offices
6. Customs declarations
7. Environment related permits (including reporting)
8. Public procurement
9. Legal information data base.

WHY MIS ARE MORE COMPLEX

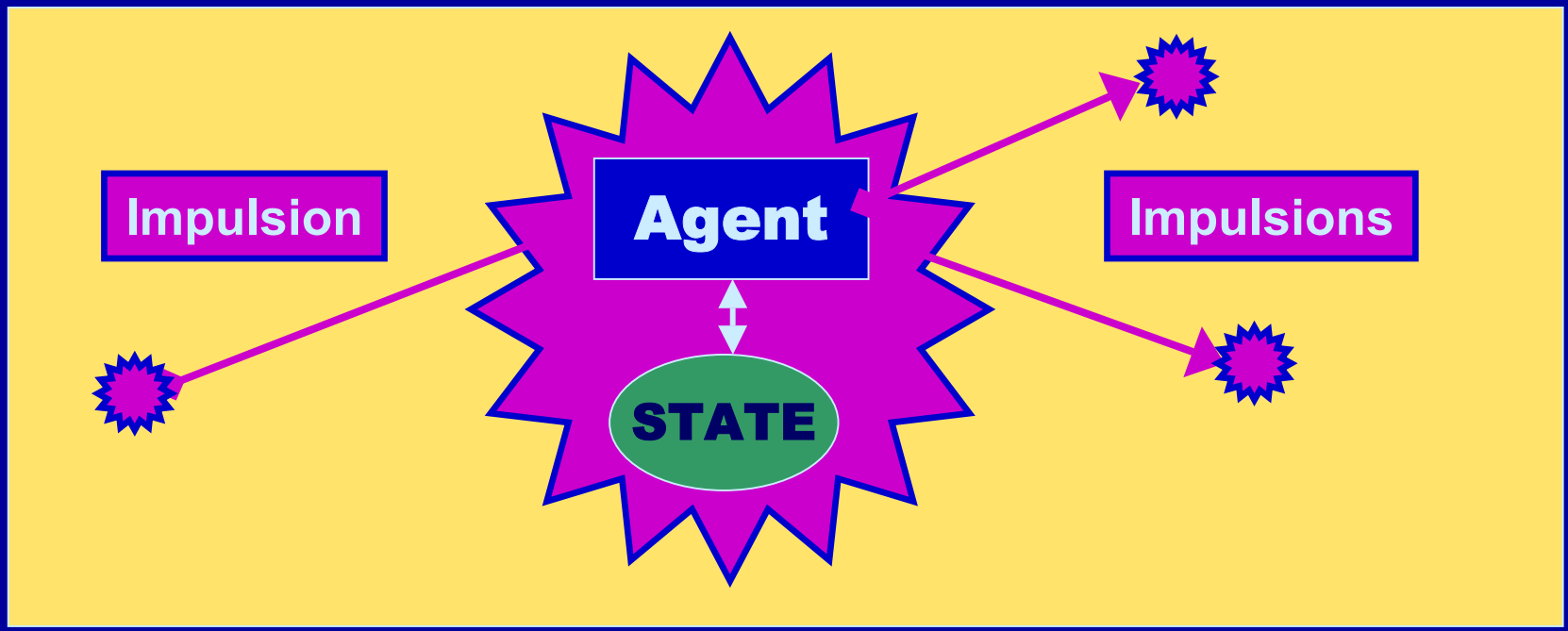
M.I.S. = Business Processes + Information Systems + Computer Network.

- The perimeter of impact of decisions are extended to more aspects: ethical, ecological, regulations, HR policies, risks management, etc ...
- Information's systems are becoming an critical part of Business Process giving competitive advantages.
- The proportion of tasks requiring Intelligence are increasing all the time to beat competition.
- Emotional aspects becomes important criteria in decision making.

NETWORKS OF INTERACTIVE AGENTS.



GENERIC ASPECTS OF AGENTS

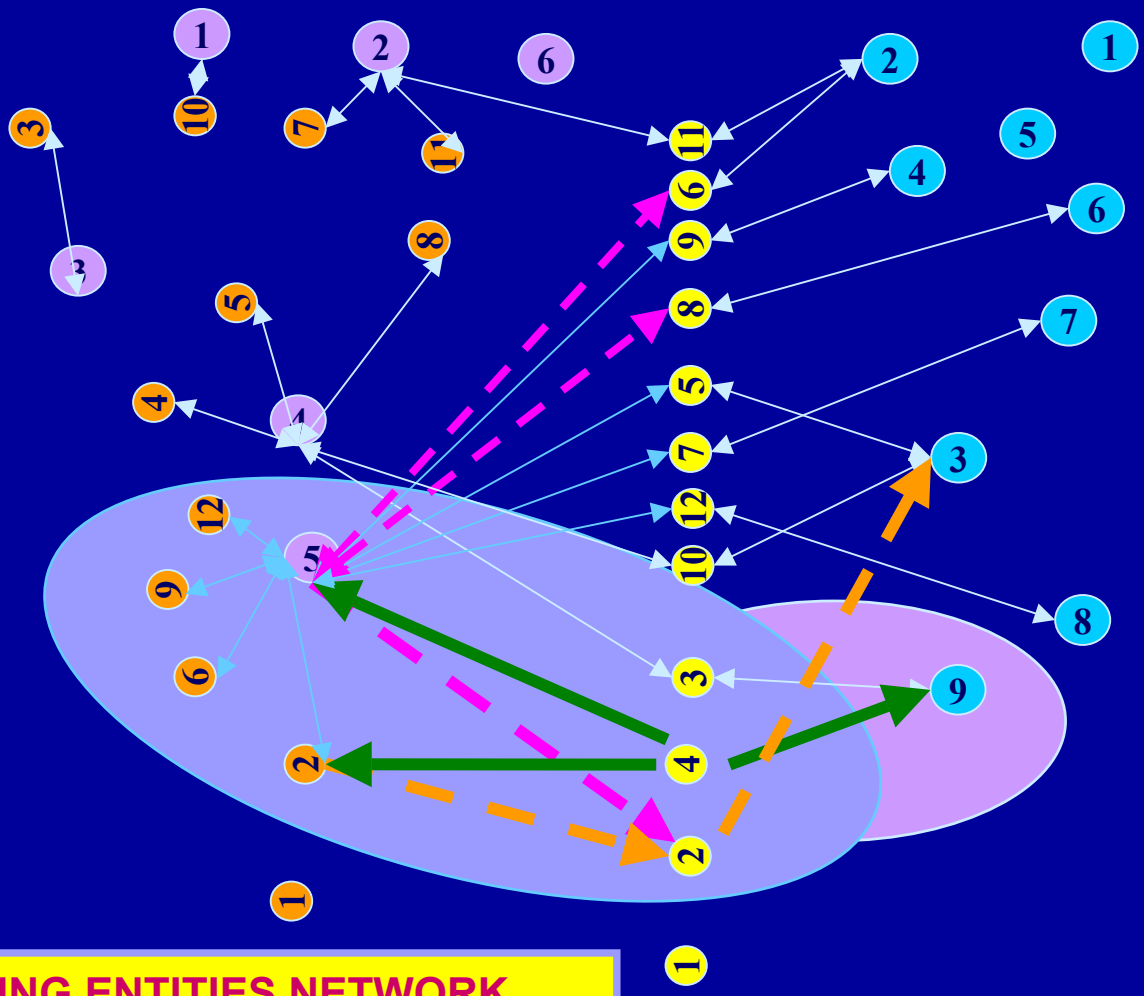


SIMPLE AGENTS :
- Impulsion
- State
- Rules

COMPLEX AGENTS:
- Sollicitation
- Responses
- Adaptation

RELATIONS :
- Recursive
- Retarded
- Non linear

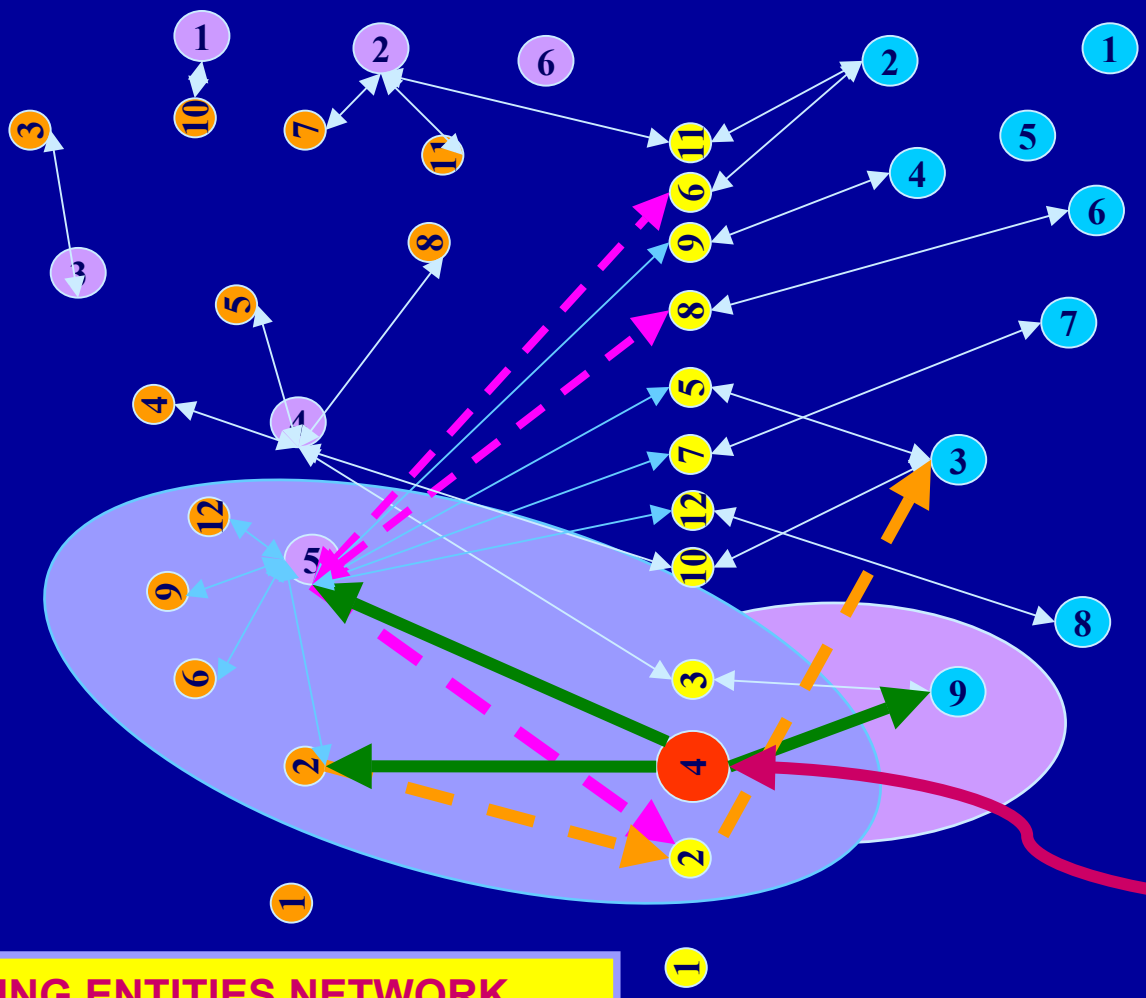
PROPAGATION IN NETWORK.



- Laon returned
- Book
- Copy returned
- Member returning
- Laon allocated
- Member served

LIVING ENTITIES NETWORK.

PROPAGATION IN NETWORK.



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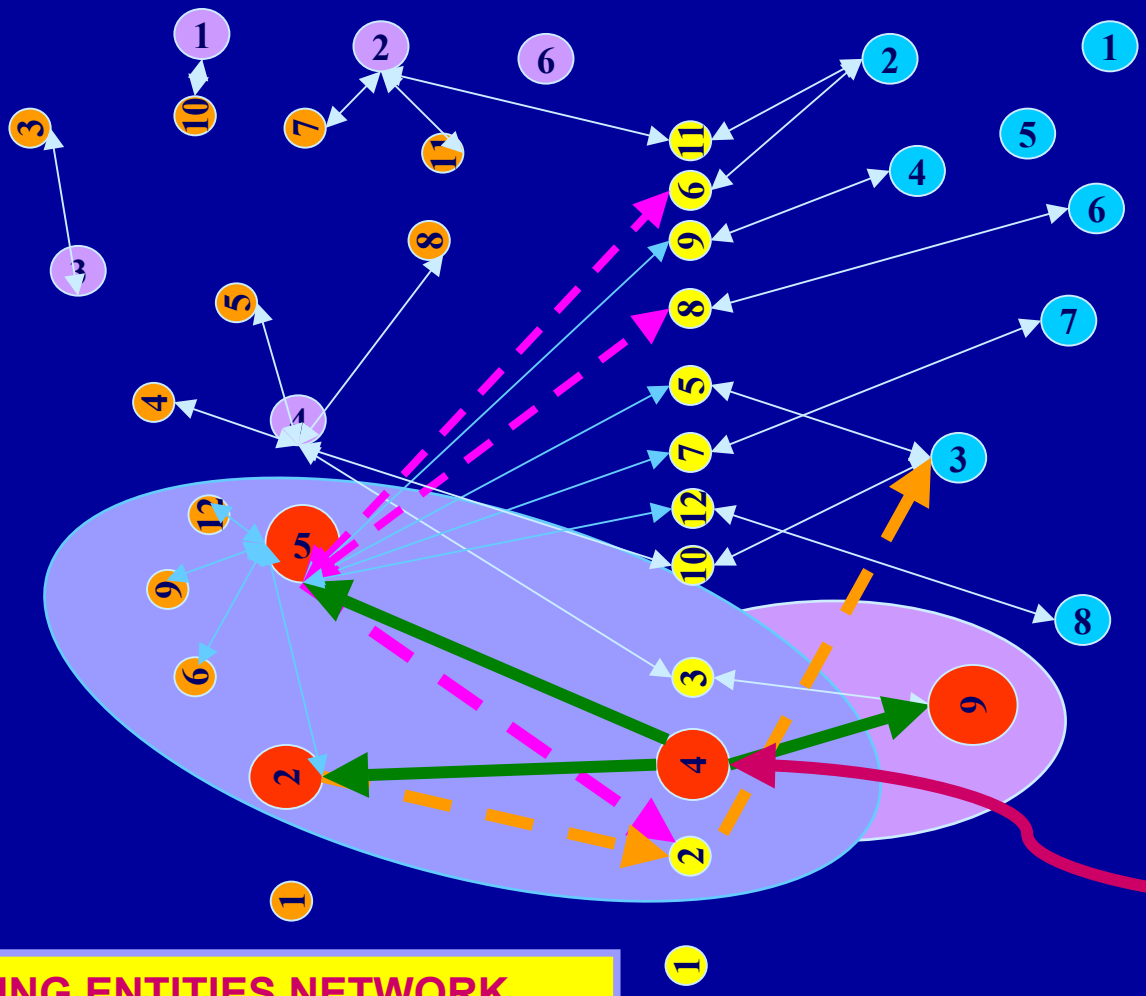

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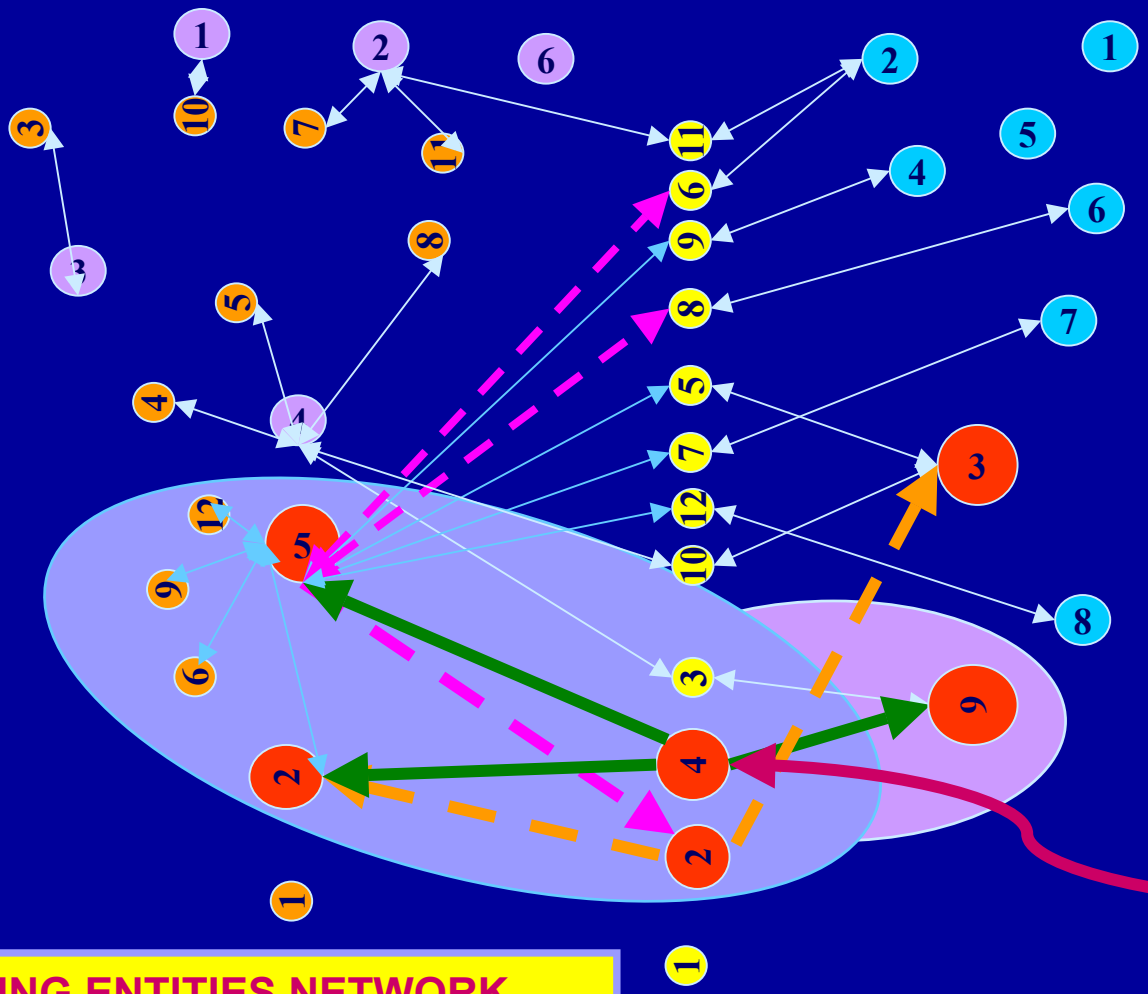

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LIVING ENTITIES NETWORK.

TYPES OF AGENTS IN A NETWORK

- Elementary Agents have a mechanical behaviour. Types of impulsion's and type of states are in small numbers.
- Complicated agents have a large number of types of impulsion's and states. But their behaviour remains predictable as impulsion's propagate to many elementary agents without feedback.
- Complex Agents are quasi unpredictable as the state after receiving an impulsion is emerging from the propagation in loops of agents.

CLUSTERS OF AGENTS MAY BE SEEN AS AGENTS

WHY IS A SYSTEM COMPLEX.

- It is not the complexity of agents behaviour, but that of the interactions between them.
- These interactions are occurring in very large numbers under the stimulation of impulsion's.
- The sources of impulsion’s are diversified : the environment but also the system itself.
- Repeated impulsion's produce influence messages, new relations and new agents.
- Complexity derives from propagation in circuits, recursion and non-linearity.
- Agents appear and die so that the system become adaptable though copying the “best” agents.

WHAT ARE M.I.S. 5 CHALLENGES.

The 5 challenges of a MIS System are :

- the way to represent the Real World in a Discrete Business Process,
- the implementation of that representation on computers to support control and execution,
- the integration of all functions triggered by Real World Events ,
- the multiple functions supporting the quality,
- understanding the dynamic of spontaneous evolution.

AGENTS OF AN INFO SYSTEM.

- All agents in an Information System are OOA objects each representing a transformation of a living entity by a processor in the Real World.
- Incoming Messages are interruptions telling that a transformation is terminated and that the entity is in consequence in a new state.
- According to the new state of the entity, the start of other transformations may be triggered.
- Outcoming Messages are sent to terminate at the same time transformations of other entities.
- An elementary agent is the representation of a transformation of an elementary entity.
- These elementary transformations are CRUD : Create, Read, Update and Delete of a transformation.

FRACTAL LEVELS OF GROUPING.

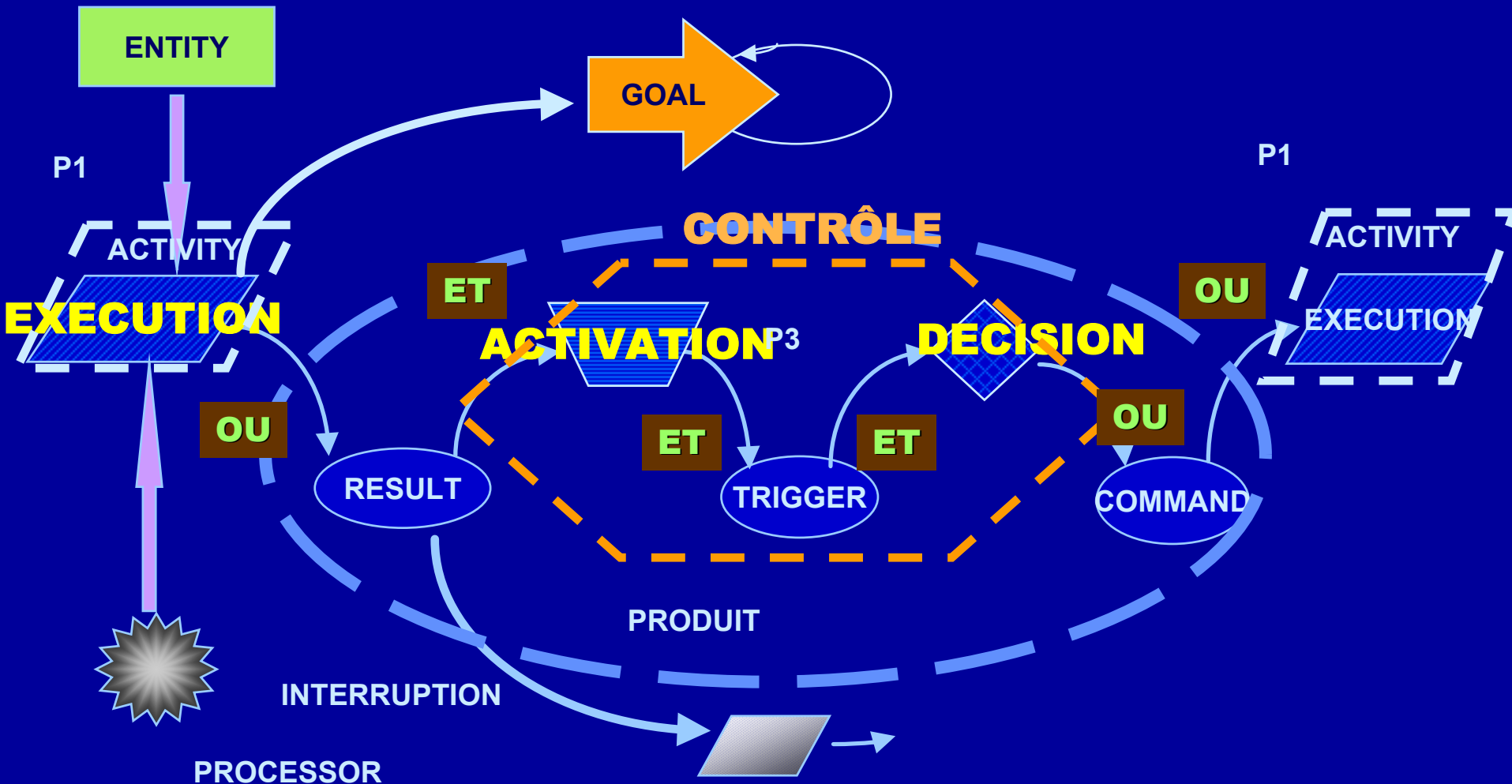
Elementary agents may be aggregated in clusters.

- Level 1 : ATOMIC AGENT = CRUD,
- Level 2 : RADICALS AGENT = network of CRUD's always associated (as "radicals" in chemistry) ,
- Level 3 : TRANSACTION AGENT = network of radical agents executed without interruption,
- Level 4 : PROCEDURE AGENT = network of cooperating transactions to get a result,
- Level 5 : APPLICATION AGENT = Sets of procedures.

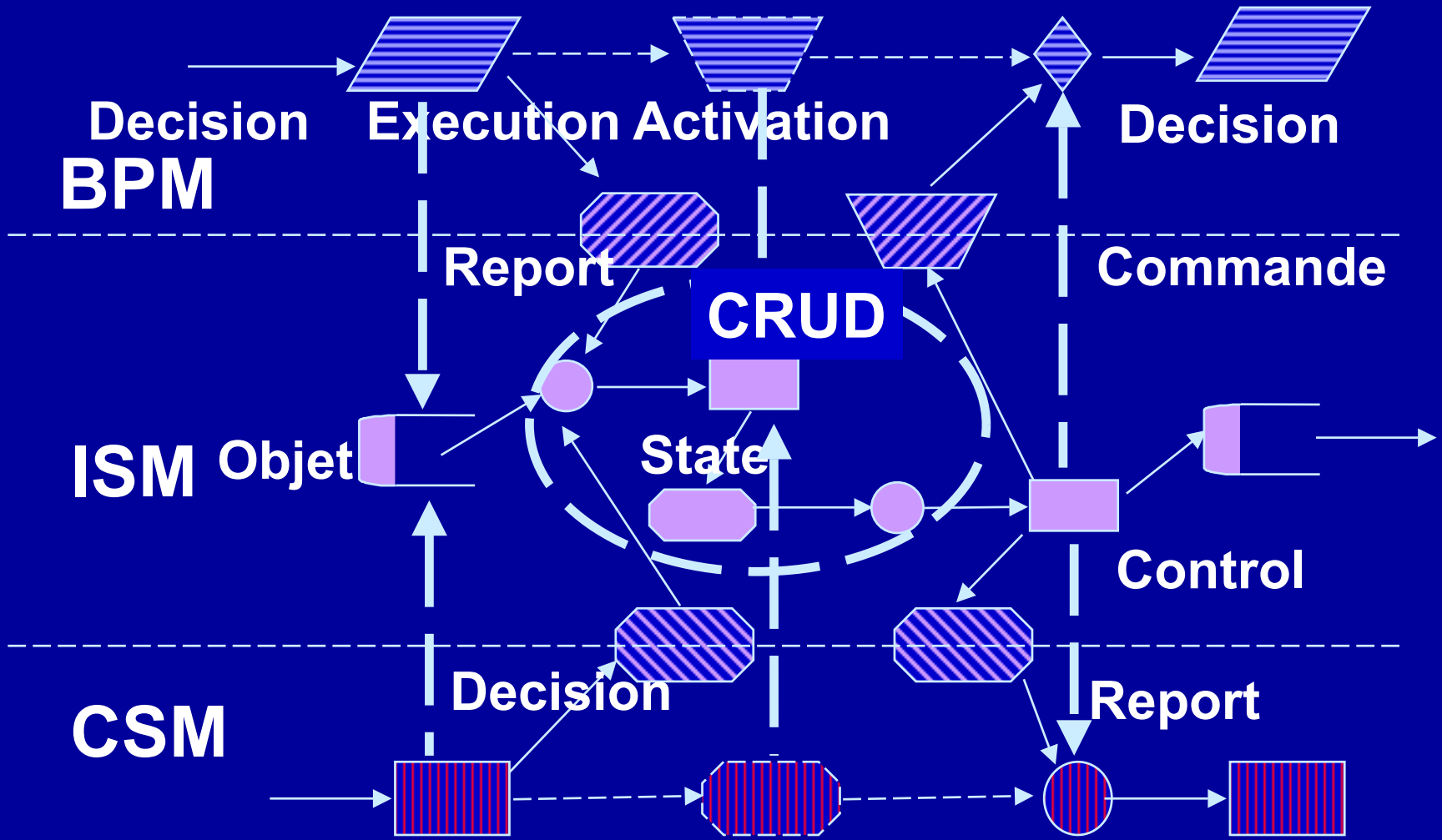
TYPES OF LIVING ENTITIES.

- Cluster agents represent the dynamic behavior of clusters of atomic entities,
- There are 3 types of living atomic entities:
  - DRIVING Entities, which Entity Life History are the skeleton of procedures.
  - TERMINAL Entities, which are the modalities of types of characteristics,
  - INTERSECTION Entities, which are linking radicals, procedures and applications.
- All messages addressed to a cluster are received by one of its entity.

STRUCTURE OF AN I.S. PROCESS.



BP and IS ATOMIC PROCESS.



INTERPRETATION FOR FLEXIBILITY.

- An IS system is always a network of OBJECTS agents as in all other networks ,
- An OBJECT is a state and methods triggered by messages changing the state and generating messages.
- Methods may be proven programs or a set of flexible specifications executed by an interpreter.
- These specifications are telling how a set of atomic agents are connected, just like DNA.
- Transactions are genes and procedures are the equivalent of chromosomes.

GENERICITY OF OBJECTS.

- Agents can be build :
  - by using Meta-Agents i.e. classes of proven agents, and creating instances through specifications,
  - or by using agents and assembling them through a control structure,
  - or by a combination of both.
- The % of generic agents that can be used are high for :
  - low level agents that are all similar,
  - services and auxiliary functions dealing with application independent services,
  - high level agents dealing with management procedures that are also similar.

MANY NETWORKS ARE SIMILAR.

Most complex networks behave like living systems.
They shows similar structures and dynamic behaviours.

- earth landscape under the impact of climate,
- continents plates under the move of internal plasma,
- electricity grids, highway's, GSM's or Internet,
- protein creation and interactions with genes,
- food webs in ecological systems,
- ant's nests, bees swarms, hordes, flocks, packs,
- memory, emotion and thinking in the brain,
- small groups as families or working teams,
- enterprise's or political organizations,
- the stock exchange and the investors,

THE EMERGENCE OF STRUCTURES

In an agent's network, every agent may have a particular pattern of interactions depending of the relations it happens to build.

An agent and all its related agents form a cluster.

The distribution of links for a particular node may be the consequence of the logic of building the relations.

Basically 3 types of logic may be observed:

⇒ The **hierarchical logic** : every node gets influenced by only one node, but it may influence many others. Parents and children are an example of such a structure.

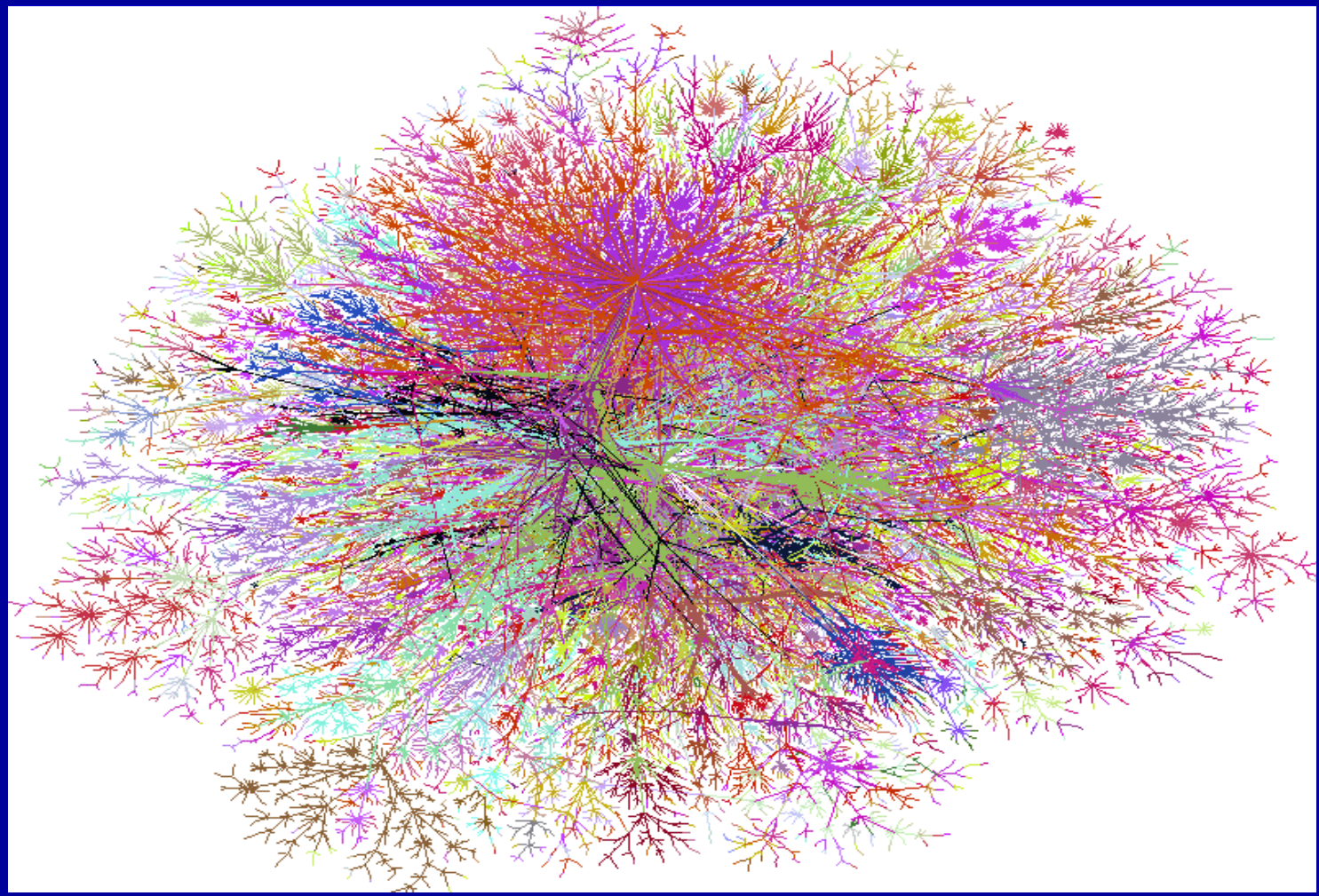
⇒ The **random logic** : any agent is connected randomly to others. Some have many connections, others only a few.

⇒ The **attraction logic** : agents tend to be connected to the ones which are attractive to them, either because they already have many connections, or because they have some common interests.

INTERNET MAPPING PROJECT:

Frequent routes

Source: The Internet Mapping Project at Lumeta Corporation



FRACTAL STRUCTURE of CLUSTERS.

This picture of the relations in the network of the Internet shows that a few nodes have a very large number of relations, whereas the number of nodes N having a certain number of relation increases exponentially with the decrease of the number K of connected nodes.

This distribution is a power law:

$$N = N_{(K=1)} * K^{-\mu} \text{ or } \log N = \log N_{(K=1)} - \mu * \log K .$$

Most natural networks demonstrate this property, because when nodes are added to a network, they always have a preferential attraction to a few other nodes. and many others, have this structure.

Such a structure, which is between a hierarchical structure and a random one is called a "Small World" structure on the edge of chaos.

It corresponds to a network that is at the same time resilient to perturbations and adaptable to new relations and new agents.

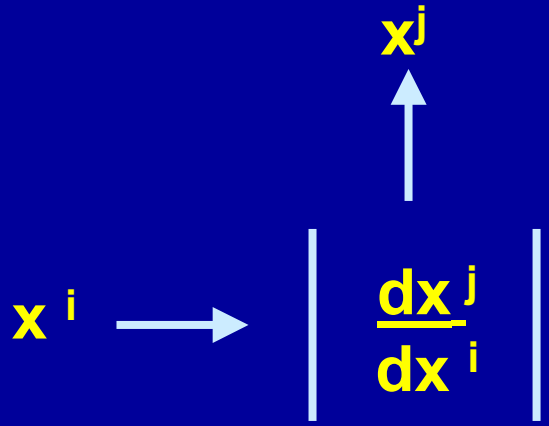
DYNAMIC PATH AND EMERGENCE

- Determinist agents change the same way each time when an impulsion is applied to an entity in a certain state.
- Clusters of agents receiving an impulsion endure an avalanche of changes by propagation of messages to a network of related agents.
- If this network contains loops, the network becomes a virtual living system.

DYNAMIC PATH AND RULES.

The dynamic path of a network is a function of the

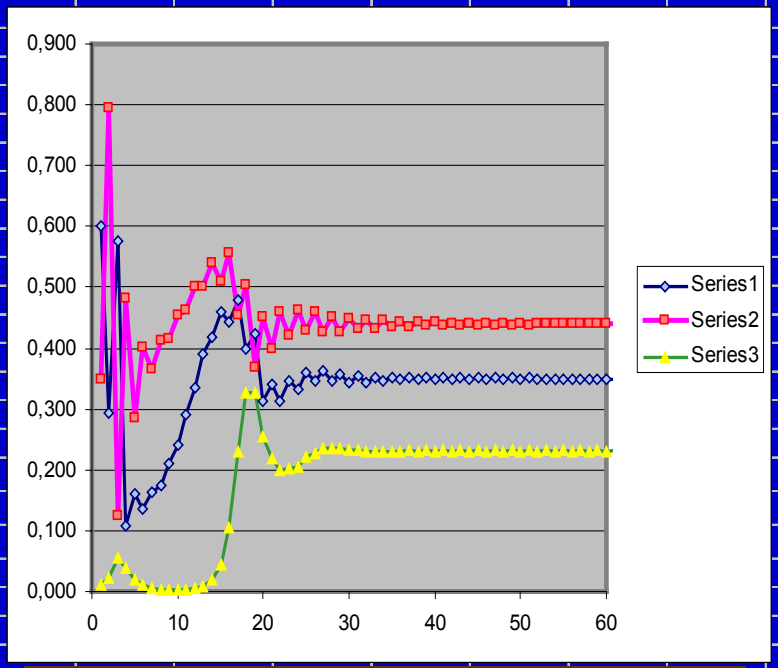
JACOBIAN MATRIX



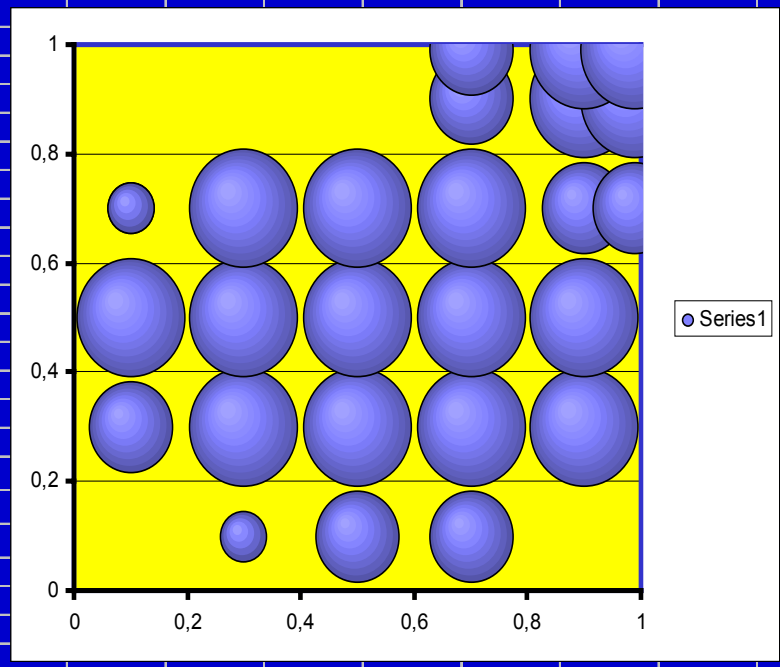
TYPICAL PATH OF EMERGING AGENTS:

- Multi-stabilité of positive loops,
- Oscillations and homeostasis of négative loops,
- Chaos and LORENTZ paths,
- Temporary life of an agent.

MUTUAL ADJUSTEMENT OF STATES



Emergence of the same result



Space state: death, stable, collapse

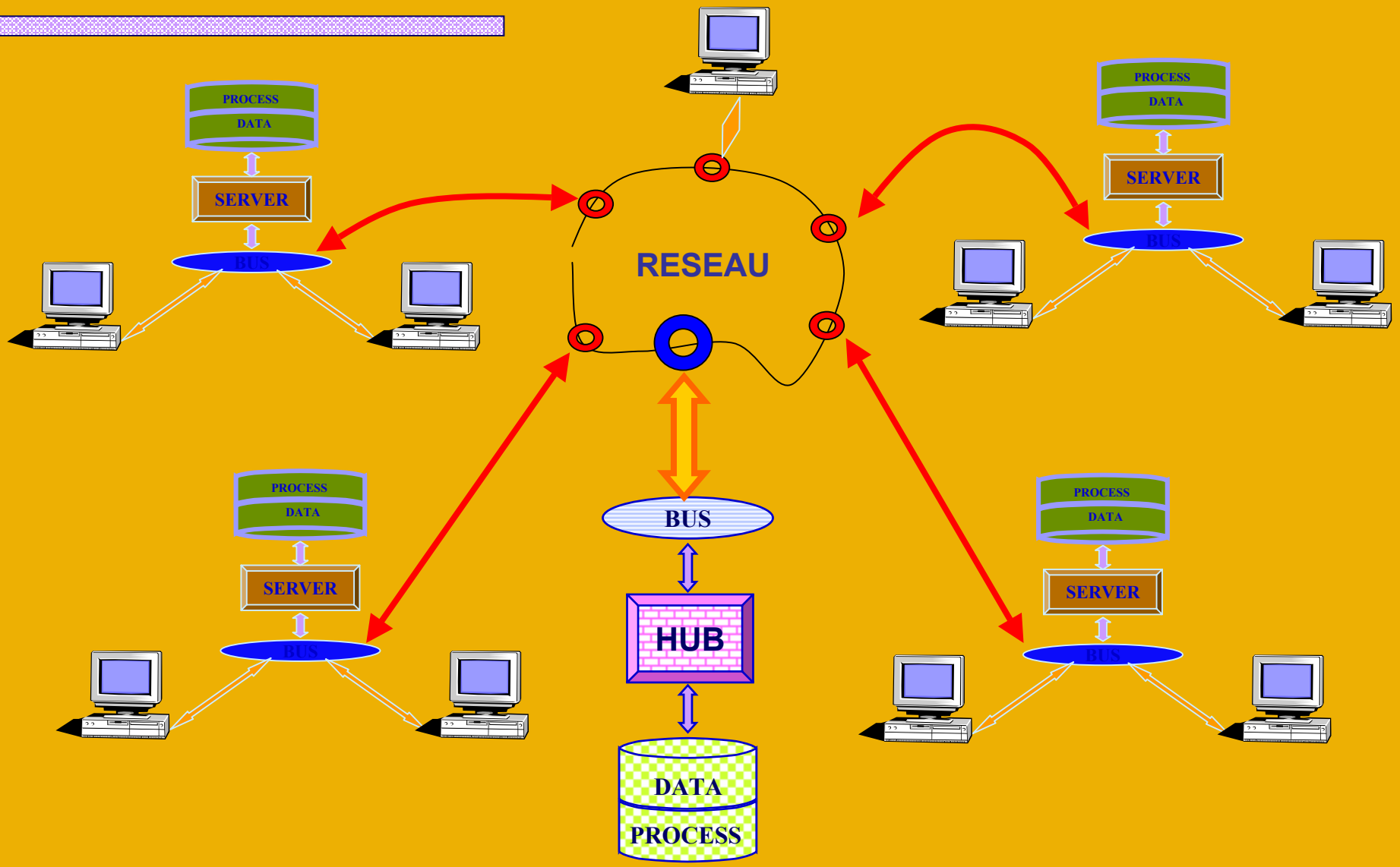
Emerging states are function of :

- **influence rules**
  AND SOMETIMES
- **of initial state.**

GLOBAL FUNCTIONAL STRUCTURE

- To provide quality services to a Business System, a M.I.S. must offer:
  - to replace people for execution and control of operational processes at all levels,
  - to support its own auxiliary functions that forbid drifts of the system,
  - to allow permanent adjustment of processes and support to Real World evolution.
- Its structure must appear as a Network of Small Worlds each specialized in an application.

NETWORK WITH A HUB

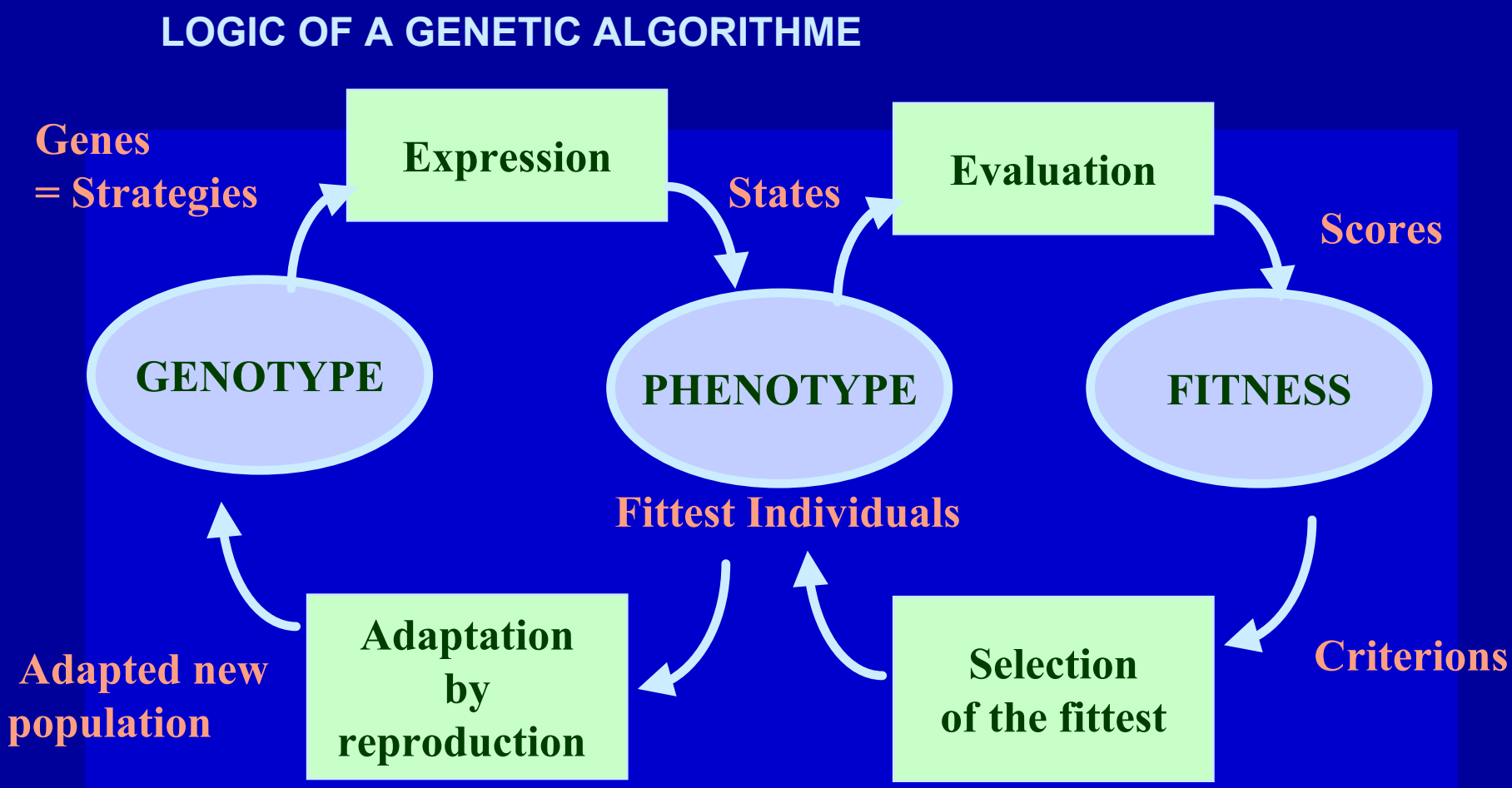


E-Gov SUPPORT ORGANIZATION

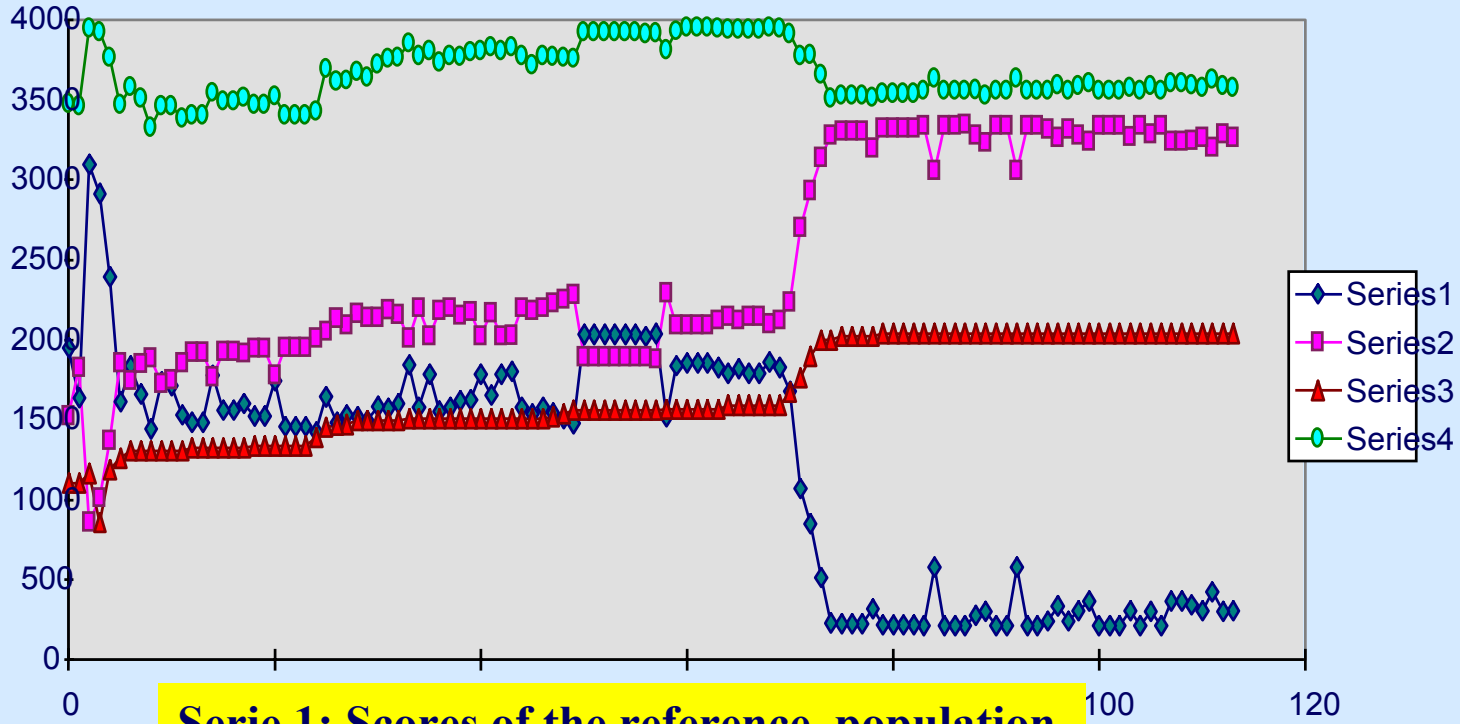
Support organization for open partnership between e-Gov structure, users, suppliers, politicians and Administration :

- Access to Government and resources,
- Consulting Committees for :
  - technical norms,
  - quality control,
  - project planning,
  - users and government officers guidance,
  - industry relation,
- Periodic benchmarking of the services,
- Customer and suppliers relationship services,
- Legal aspects management and development.

ADAPTATION BY GENERATIONS.



DARWINIAN ADAPTATION.



Serie 1: Scores of the reference population
Serie 2: Scores of the adaptable population
Serie 3: Scores of the 6 best individuals
Serie 4: Total Scores of both populations

BRAINS AS A NETWORK.

- The brain controlling people behavior appears to be a nice example of a network of interactive adaptive agents,
- Agents are the neurons and messages are the neurotransmitters going through the synaptic connections,
- Memes are patterns of synaptic connections loops corresponding to Stereotypes and SOP : Standard Operating Processes.
- The criteria for controlling the death and development of new memes, are the pain and pleasure generated by neurons.

WORLD SYSTEM BRAIN.

- The development of INTERNET and LAN'S lead to a structure that becomes similar to the brain.
- Messages are becoming more numerous every day, propagating information's and good processes through the world.
- It will make the word more intelligent if R&D for new SOP's and institutional structures as well as selection criteria are adequate.
- But it will fail without creating the equivalent of an immunological system to stop virus, spam and messages at the service of unethical actions.

THE 3 TYPES OF EMERGENCE.

COMPLEX SYSTEMS BEHAVIOURS COMES FROM THREE TYPES OF RECURRING INTERACTIONS.

- Mutual adjustments of agents exerting on others recursive influences, explains dynamic stable path, but also oscillation, chaos or collapsing.
- Disappearance and Generation of new relations according to agent's attraction explain the emergence of fractal clusters structures.
- Disappearance and Generation of new agents according to their fitness explain adaptation of networks to changes in their environment.

COMPLEX SYSTEM BUILDING.

- Methodologies acting at 4 levels :
  - impulsion's for local aspects,
  - procedures for propagation and loops,
  - addition of new relations and better agents,
  - selection criteria's driving emergence of progress.
- Integration of human emotional irrational aspects of people using the system,
- Development through incremental phases tracing the natural emergence of structures and good components.
- Libraries of reusable components will become critical for quality and speed of development.

MORPHOGENESIS.

- MORPHOGENESIS is the process used by nature to grow living beings from a fertilize single ovule.
- This process is based on reproducing for each individual the complete path of life development.
- It is the consequence of multi-stable cells differentiation triggered by a threshold presence of proteins produced by the existing cells network,
- At the same time, specialized clusters of cells are built and tested by making them work together,
- This is a trial and error process requiring as much as 10 times more cells produced than those composing the baby at birth time.

A VIRTUAL LIVING I.S. : ADACS.

IS complex systems, will be developed like brains by training them how to support Business Processes.

1. DBase, DCommunication, DDisplay services,
2. Auxiliary first services installation
3. CRUD of main processes driving entities (ELH),
4. CRUD of intersections entities linking processes,
5. Enriching the meta-objects library,
6. Drawing the map of the network to check loops,
7. Defining the values used for objects selection,
8. Improving all human and entities agents by cycles.

STEPS IN e-Gov SERVICES DEVELOPMENT.

The unique virtual gate delivering services work at 4 levels of complexity:

1. **Information level :** **A dialog with the Portal guides the user toward the site adequate for his problem. The access rights of the users must be checked by his identity and certificates allowed to him. Then by browsing on this site, it delivers information's on government matters, on rights and procedures and formulas. On this level the administration does not reply by mail but by post or to the person at a gate,**
2. **Transaction level :** **In this level, the user may return information's : filled intelligent formulas, opinions on a forum, mails to contact persons, advanced payments for services. The administration reply by sending his answers like acknowledgement, authorisation, official documents . The identity of the sender must be explicit. All personal information's sent with this procedure can be checked by the owner of it,**
3. **Procedure level :** **Here the user can start a procedure and the e-Gov system manage the work flow of the different tasks to be executed by a variety of people. It suggests partners for other tasks, supervises the agenda and sends recalls,**
4. **Negotiation level :** **At this level the procedure may include negotiations involving groups of people. The progress of building a consensus must be enhanced.**

CONCLUSION : M.I.S. are VLS.

- The model for a M.I.S is like that of an ecological system of individuals of various species.
- The BIOS Project has proved that only complex diversified systems can survive durably by rebuilding their equilibrium at every moment.
- MIS people and program's components interact also between each others in circuits at the edge of chaos. Flexibility is critical to allow this permanent adjustment.
- The user's brain is also an adaptive ecological system of ideas bouncing one against the others before stabilizing when they interact in reinforcing loops.

M.I.S. should be built like Virtual Living System.