Finding Maturity Evolution Paths for Organisational use of Information - A *Moviflor* Case Study

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***Abstract* – Exploiting the full potential of information, by adequately accessing, processing and using it as needed is a crucial but challenging ability for Organisations, given their growing capacity of easily capturing and storing high volumes of data. Modern Organisations thus need to aspire to an accurate and adequate use of Information, if they want to enable their teams to make well-informed business decisions.**

Building upon the concepts of Business Maturity, Enterprise Modelling and Business Transformation, the goal of this thesis is to provide engineering methods to construct a design model able to describe Organisations' maturity evolution paths regarding their actors' use of information, eventually culminating in Business Intelligence.

The proposed model is based on a bottom-up approach to assess Organisational Maturity in daily use of information and subsequently define related maturity evolution paths by abstracting enterprise complexity; and aims at providing a more detailed awareness on how Organisations have to pilot trough their evolution paths, progressively and adequately gaining capacities and maturity in information use.

1 Introduction

Current Information Technology and Information Systems enable Organisations to store huge amounts of information about their activity [1]. This recent capacity of easily capturing and storing high volumes of information can be of great advantage to Organisations if effectively managed, but can bring equally great harms if not. In fact, having more information do not necessarily bring greater value [2].

It is thus critical for Organisations to know whether the stored information is useful or useless, since the information reliability will profoundly affect decision-making processes throughout the organisation [3]. Organisations therefore need to learn how to use and manage information intelligently, so as to act more efficiently and effectively.

Beyond Organisations' capability of Information Management, they need to be able to view and treat information as a strategic resource, like any other critical organisational resource, which can be extremely powerful if correctly converted into organisational knowledge.

In order to do so, Organisations need to aspire to an accurate and adequate use of its Information, enabling to accomplish tasks more accurately and operate more competitively, thus enhancing business performance.

Correct Information Management and use in an Organisation is the foundation for it to prosper, and will ultimately lead to Information and Business Intelligence.

A successful Business Intelligence solution is the ultimate tool to the success of an Organisation. However, the implementation of such a solution without previously understanding how the entire organisation works could have negative effects on a business. It is thus crucial for Organisations to clearly understand where they are, in order to realise where they need to be.

2 Problem Statement

The focus of this research is to find a way of analysing Organisational use of information, in order to provide a definition of potential business evolution towards Business Intelligence.

This organisational evolution must be a sustained evolution, effectively adjusted to enterprise reality. Organisations must have realistic and adequate views of themselves, on top of accurate information management capabilities, if they want to build a sustainable future.

Additionally, Organisational maturity must be taken into account and carefully analysed, so that it is possible to understand if required foundations exist for the Organisation to evolve.

This research thus aims at finding engineering methods to construct a design model able to describe evolution paths of Organisation's maturity regarding its actor's use of information, eventually culminating in Business Intelligence.

This thesis problem is thus defined as a

"Bottom-up approach to define Maturity Evolution paths for Organisational use of Information."

3 Related Work

3.1 Business Maturity

Maturity Models are a widely accepted instrument for systematically documenting and guiding the development and transformation of organisations on the basis of best or common practices [4]. They have become an established means in the IS community to support organisations when it comes to effective management and continuous improvement for complex, multi-faceted phenomena [5].

A Maturity Model typically consists of a sequence of maturity levels for a class of objects, where each level requires the objects on that level to achieve certain requirements [6]. When all the requirements of a level are achieved and the Organisation is stable, having reached the peak of the level where it is in, it will feel the need to evolve and will be ready to reach the next maturity level.

Maturity Models are based on a set of important characteristics [6]: *Object of Maturity Assessment* – which can be technologies, systems, processes, etc. –, *Dimensions* (Specific capability areas that describe different aspects of the maturity's assessment object), *Levels* (Maturity states of the object under assessment), *Maturity Principle* – Maturity Models can be continuous, allowing for a scoring of characteristics at different levels, or staged, requiring that all characteristics of a distinct level be achieved –, and *Assessment* – which can be qualitative, by the means of interviews, or quantitative, like questionnaires with scales –.

Numerous Maturity Models have been developed over the years, most of which are defined as "fixed-level" models. Fixed-level Maturity Models are usually characterised by a fixed number of generic maturity levels – usually around five –, where each maturity level consists of a series of processes that have to be implemented. Those models are well suited to benchmarking, but not so much for incremental improvement.

Focus Area Maturity Models

M. Steenbergen et al. [7] defend that the notion of generic maturity levels is an oversimplification, and proposed the creation of a *Focus Area Maturity Model.* This model is based on a number of focus areas that have to be individually developed in order to achieve maturity in a functional domain. Such model defines a method to develop step-by-step improvement in each focus area in order to reach progressively mature capabilities in specific functional domains, and allows picturing different evolution states in a given domain.

An example of Focus Area Maturity Model is further depicted in Figure 1.

In this example, the functional domain under analysis is the one of Enterprise Architecture. Focus Areas of the functional domain are listed on the Rows of the matrix, while the Columns represent progressive overall maturity scale (From 0, being the lowest, to 13, being the highest).

Each Focus Area has progressively mature capabilities (defined as A, B and C), which will define maturity evolution through the maturity scale. In the Enterprise Architecture example, the capabilities are defined as follows:

A – Architecture used informatively
B – Architecture used to steer content
C – Architecture integrated into the organisation

In this Maturity Model, an organisation is said to be at the maturity scale represented by the rightmost column for which the organisation has achieved all focus area capabilities positioned in that column and in all columns to its left. Thus, despite the development of some of the focus areas, on the whole, the organisation in Figure 1 is still only at maturity scale 1.

Maturity Scale / Focus Area	0	1	2	3	4	5	6	7	8	9	10	11	12	13
Development of architecture		A			B			C						
Use of architecture			A			B				C				
Alignment with business		A				B				C				
Alignment with the development process			A				B		C					
Alignment with operations					A			B			C			
Relationship to the as-is state					A				B					
Roles and responsibilities				A		B					C			
Coordination of developments							A			B				
Monitoring				A		B		C		D				
Quality management								A		B			C	
Maintenance of the architectural process							A		B		C			
Maintenance of architectural deliverables					A			B					C	
Commitment and motivation		A					B		C					
Architectural roles and training				A		B			C			D		
Use of an architectural method				A						B				C
Consultation			A		B				C					
Architectural tools							A				B			C
Budgeting and planning				A							B		C	

Figure 1 - Focus Area Maturity Model for the Functional Domain of Enterprise Architecture [7]

3.2 Enterprise Modelling

Organisations are regarded as complex systems that emerge from the interactions among human and non-human agents. In order to facilitate the communication among organisation stakeholders and provide means for them to have a global vision of it, recent evolution of the Information Systems field has been marked by the emphasis given to Enterprise Modelling (EM), the process that encompasses the construction of models and other modelling activities [8], .

Generally proposed EM frameworks are essentially focused on activities, and lack capturing individual behaviour. Since those dynamics can only be deduced from actors' roles and activities, the referred frameworks are unable to model the actual behaviour of specific individuals, rather modelling their generic, expected behaviour. An additional issue of existing EM frameworks is that they have no means of reflecting the different and frequently incoherent views that different agents have of the organisation [8].

In order to address all those issues, *M. Zacarias et al.* proposed a framework to enrich EM by capturing and representing personal and inter-personal work patterns from actual actions and interactions, and relating them with enterprise activities and resources [9]

The suggested framework is built upon five fundamental concepts:

1. *Resources:*

   Entities required for the operation of an organisation. They may be physical or abstract, active or passive.

2. Activities

   Descriptions of what organisations do. The definition of those organisational activities implies shared understandings among participating subjects about: the set of resources used (inputs) or produced (outputs), its specific outcomes, and the procedure required to transform inputs into outputs.

3. Agents

   Agents are a special kind of physical and active entity, which have capabilities of performing, coordinating and designing activities; providing, consuming, managing, and designing resources; and monitoring, coordinating, and designing their own activity, as well as the activity of other agents.

   Agents perform actions to change the state of a given resource-related item and are capable of communicative actions exchanged between two given agents, or interactions.

4. Roles

   Roles are the observable behaviour of agents in particular situations.

5. Contexts

   Contexts are the network of entities (agents, resources, and rules) that are relevant for an agent in a given situation.

The framework follows an Agent-Oriented modelling method, encompassing a series of agent levels, with associated modelling concepts:

"Single-Agent" Level

This level focuses on single-agent multitasking capabilities and activation/suspension of roles related to the task performed at a given moment, eventually consuming resources.

"Two-Agents" Level

This level represents a collective agent composed of two individuals, called as *dyads*. Dyads define relations between two single agents and they are an essential building block of social networks.

"2-More Agents" Level

This "Group Agent Level", represents *groups of individuals* acting as one. They generally have a group structure; follow a common goal and act following a joint intention and commitment.

"All Agents" Level

This level represents the *whole Organisation*, following organisational structure, rules and patterns. It is generally guided by social an interaction rules.

This framework essentially aims at addressing both agent and organisation complexity through an integration of agent and enterprise architectures: the organisation is modelled as a dynamic network of activity and resource-related agents. This way, it can fulfil its purpose of capturing agent-enacted behaviour, as opposed to traditional modelling of expected behaviour.

By capturing this kind of information, one is able to uncover individual and collective work practices and to evaluate how these practices evolve in time [10].

The framework is further depicted in Figure 2.

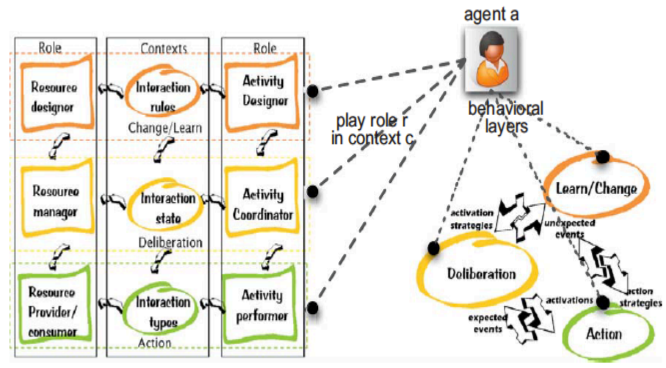

Fig. 8. Agent architecture and dynamics.

Figure 2 - Framework Agent Architecture and Dynamics

Actual agent behaviour results from interplay between agent autonomy and the behaviour determined by its activity and resource-related roles. Consequently, different agents playing identical roles exhibit similar, but non-identical behaviour, thus confirming that human agents do not fully follow prescribed behaviour, but rather cause deviations between designed activities and execution [8].

3.3 Enterprise Transformation

Enterprise Transformation is defined as a designed and fundamental change, in contrast to ad hoc, routine change. It is a purposeful steering intervention into an enterprise's evolution, in order to respond to perceived opportunities, deficiencies or threats [11].

In order to deal with Enterprise Transformation, *R.Abraham et al.* [12] introduces the use of Control Theory, in order to describe dynamic aspects of the Organisational system, turning to the concept of "feedback loops".

Feedback Loops

A feedback loop consists of an *observer* that records environmental data, a *modeller* that interprets the data and calculates corrective actions, and a *controller* that influences the system based on the input from the modeller.

The controller component is able to compute corrective measures by constantly observing system states and comparing observed data against system goals, and subsequently changes system variables in order to realign them to system goals.

Model-updating mechanisms are crucial: if the observer or modeller part in any feedback loop fails, then the system cannot be purposefully controlled or transformed.

The Feedback Loop theory is further illustrated with a vehicle system controller in Figure 3.

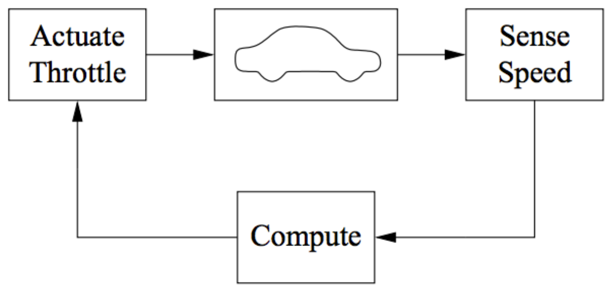

Figure 3 - Feedback system for controlling the speed of a vehicle [13]

The speed of the vehicle is measured and compared to the desired speed within the "Compute" block *(Observer)*. Based on the difference in the actual and desired speeds *(Modeller)*, the throttle – or brake – is used to modify the force applied to the vehicle by the engine, drive train and wheels *(Controller)* [13]. The actual car speed can thus be kept as close to the desired speed as possible.

Applying the feedback loops theory to the business context, organisations can be considered as complex systems in which several feedback loops run in parallel. In that way, *R.Abraham et al.* illustrate feedback loops in enterprises as depicted in Figure 4.

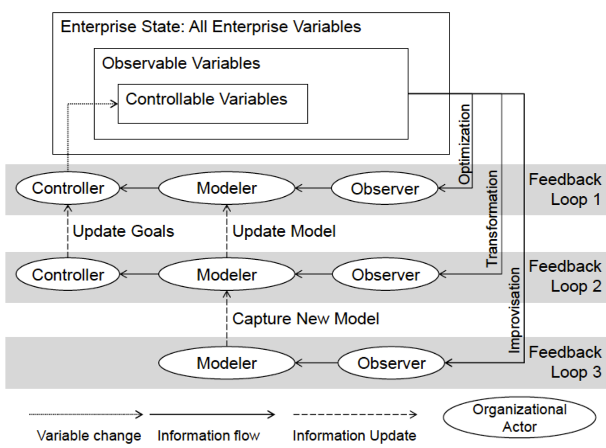

Figure 4 - Feedback Loops in Enterprises [12]

Enterprise State

Enterprise state consists of all enterprise variables, which define the Organisational Configuration at a given moment in time.

Observer

All observable information provides inputs to the observer. Overall descriptions of business processes, performance indicators and dashboards provide information on various organisational subsystems.

Modeller

Set of business rules and policies established in order to guide the implementation of the overall goals. These policies and business rules enable to restrict design freedom of organisational agents.

Controller

Change controllable variables in order to achieve the design of the new organisational configuration.

4 Solution Design

A "Bottom-Up Approach"

In an effort to simplify Organisations' complex interplay of actors in a multifaceted ecosystem, *M.Zacarias et al* [8] introduced a significant Agent-Oriented Framework that helps breaking down the Organisational structure in different complexity levels, which will be the basis for our "bottom-up" solution feature.

Our proposed approach will consider the previously defined levels of complexity: *Single-Agent*, Two Agents (or *Dyad*), 2-More Agents (or *Group*) and All Agents (or *Organisation*) as illustrated in Figure 5.

Behaviour at each Agent individual level will affect the rest of the Agents throughout the entire Organisation.

This bottom-up approach allows for us to gradually increase in complexity while keeping a structured and simplified vision of the organisation. By building up on those simple notions, we are able to understand that an organisation, in every moment, is composed of unique agent configurations.

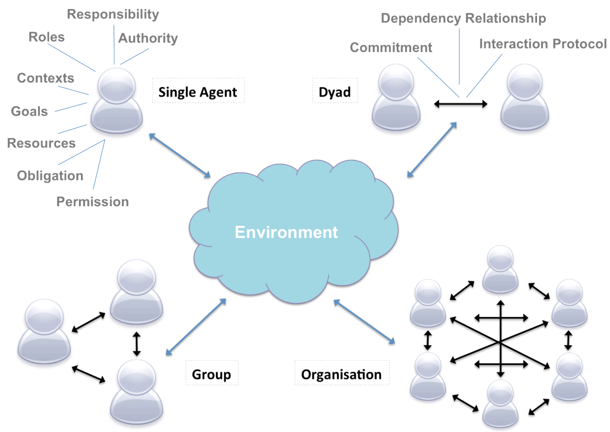

Figure 5 - Bottom-Up Approach

Defining Organisational Use of Information

Theoretical foundations on Business Transformation provided very important and useful insights into what will be the foundation for the agent use of information in enterprises analysis.

The notion of Feedback Loops in Enterprises and further definitions of its basic notions of *Enterprise State, Observer, Modeller* and *Controller* will be useful in order to understand the decision-making process of organisational agents, and the way they use and process information.

Applying those notions to our research object, we are able to construct the following "Agent Decision-Making Feedback Loop" process:

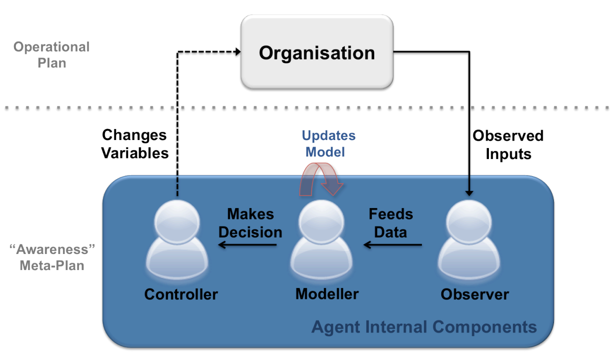

Figure 6 - Agent Decision-Making Feedback Loop

Agents need a set of inputs (*Observed Information*) in order to make a set of informed decisions in their particular contexts, considering the scope of their authority and responsibility. Those inputs are observed resources and their individual state in a given moment.

The Agent then processes the inputs against his current mindset (The *Agent Modelled View* of the Organisational state), which consist of its interpretation of the world at that precise moment. This Agent interpretation – or conceptual map – of the Organisation enables him to compute the observed inputs and eventually update his initially modelled "World View".

Finally, according to the decisions he made, the Agent acts and changes the controllable variables of the Organisation (*Controller* action).

At each moment, the feedback loop will exist on two plans of the Agent context: the Operational Plan – Organisation configuration, with all its variables, its subset of observable variables, and its sub-subset of controllable variables –, and a meta-plan, here called the "Awareness Plan", where the observer, modeller and controller stages of the loop take place.

Observed, Modelled and Controlled informational entities are the same ("All variables") and, if the Organisation Information Architecture enables them, its Agents will have a common view and understanding of those entities.

Fully and clearly expressed, this Feedback Loop allows for individual agent self-awareness, which is the basis for a bottom-up approach towards the entire Organisation self-awareness.

We argue that the studied decision-making loop can *uniformly be applied to all levels of agent complexity*, since the Feedback Loop will be the same whether we are studying individual or collective Agents. In fact, the Observer, Modeller and Controller components of the "Agent Decision-Making Feedback Loop" can be seen as a "black box", since the overall process will be exactly as previously described, regardless of what happens inside the "black box" (i.e. The internal mechanism upon which agents observe information and consequently decide to make determined decisions in order to act).

Putting the Pieces Together

In order to reach our proposed solution for a *"Bottom-up approach to define Maturity Evolution paths for Organisational use of Information*" we will combine the described "Agent Decision-Making Feedback Loop" with the studied concepts of Business Maturity.

We thus propose that, in order to define Maturity Evolution Paths for Organisational use of Information, the objects *of maturity assessment and evolution* are the components of our "Feedback Loop": the *Observer, the Modeller and the Controller*. Each one of those components can have distinct behaviours depending on information use in a given Organisation.

We argue that maturity levels do not change continuously since they are rooted in people. The evolution thus takes place in the organisational agents: it is them who need to evolve by learning, and ultimately contributing to overall business transformation.

Further exploring this proposed solution, we will define maturity evolution levels for each one of those components, as follows:

<u>Observer Maturity Levels</u>

1. **Unreliable inputs** [Low Observability Level]

Data quality issues lead to an overall data inconsistency. Due to a lack of Information Architecture, Organisational Agents have no harmonised and common understandings on global informational organisation concepts.

2. **Reliable inputs, Unsuited Decision Support System** [Medium Observability Level]

Data collection and storage processes guarantee data quality and consistency. The outset of Information Architecture in combination with reliable data allows for a common interpretation of information concepts.

Information aggregation in order to support decision-making is unsuited to individual needs.

3. **Reliable inputs, Optimised Decision Support System** [High Observability Level]

Data and Information Architecture maturity allows for adequate and accurate decision-making processes based on optimised Decision Support Systems.

<u>Modeller Maturity Levels</u>

1. **No business rules and policies** [Low Modeller Level]

Lack of business rules and policies that guide agents towards overall business goals implementation, which enable for Agent design freedom – Agents create their own modelled "world view" –.

2. **Scarce business rules and policies** [Medium Modeller Level]

The Organisation establishes a set of business rules and policies in order to guide the implementation of overall goals, thus restricting design freedom of organisational agents.

Those rules and policies, whilst providing common goals, are adapted to individual agent context and characteristics – each one creates his own mindset –.

3. **Optimised business rules and policies** [High Modeller Level]

The established set of business rules can be programmed in order to automatically generate possible agent behaviour based on Observed information (inputs). This allows for predicting possible agent action outcomes in near real-time, and significantly reduces agent freedom.

<u>Controller Maturity Levels</u>

Agent action in order to change Organisational variables presents no maturity levels. The performed controlling action is linear and has only one dimension.

This vision of maturity evolution of the Observer, Modeller and Controller components represents the methodological basis of the present thesis, in order to assess the overall Organisation maturity level.

In fact, given our "Bottom-Up" approach, we argue that the overall maturity level of Organisational Use of Information is a combination of its Agents' maturity levels of information use. The maturity analysis will thus be applied at Agent-level, and not on the overall Organisation level.

Combinations of Observer, Modeller and Controller maturity levels will define a "point" in the Agent maturity evolution path.

Since it is impossible to exactly define such a path, given the complexity of the studied domain, the defined evolution paths are in reality "meta-evolution paths" that represent approximate agent evolution paths. We argue that the meta-evolution path is essentially the same for all agents, and that what changes is the action scope.

Focus Area Maturity Model for Organisational Use of Information

	0	1	2	3	4	5	6	7	8	9	10	11	12	13
Observed Information		A			B					C				
Modelled Information		A					B						C	
Overall Defined Maturity Level		LOW					MEDIUM			HIGH			HIGHEST	

A - Unreliable / Inexistant [Level 1]
B - Unsuited / Scarce [Level 2]
C - Optimised [Level 3]

Figure 7 - Focus Area Maturity Model for Organisational Use of Information

Designed Solution

Our solution design of evolution paths is rooted in the previously studied Focus Area Maturity Model, as it provides for a better adaptation to a specific organisation, acknowledging that each company is different and has unique configurations.

We argue that this model provides us an adequate way of representing the incremental improvement of the particular domain of Organisational Use of Information, grasping unique configurations of Observer, Modeller and Controller maturity levels in real-world organisations.

We thus propose a “Focus Area Maturity Model for the functional domain of Information Use in Organisations”, depicted in Figure 7.

The “Controller” component is not considered in this model, since it does not present maturity levels – as argued earlier in this section –.

The position of the letters in the matrix – defining progressively mature capabilities in the Observer and Modeller domains – indicates the order in which the capabilities of the different components must be addressed and implemented in order to gradually evolve information use in a balanced manner.

Where to position the letters in the matrix is determined by further research in individual focus area characteristics and particularities [7].

The proposed capabilities’ position in the solution matrix is thus a preliminary proposal and can be subject to future adjustments, potentially determined by further research and analysis in this field.

In order to provide a better vision of “Evolution Paths” for organisational use of information – as it is the problem we proposed to solve –, we further analyse this Observer and Modeller capabilities evolution.

Based on the “Focus Area Maturity Model for Organisational Use of Information”, we propose another rearranged matrix that provides for a clearer visualisation of said “paths”, as depicted below:

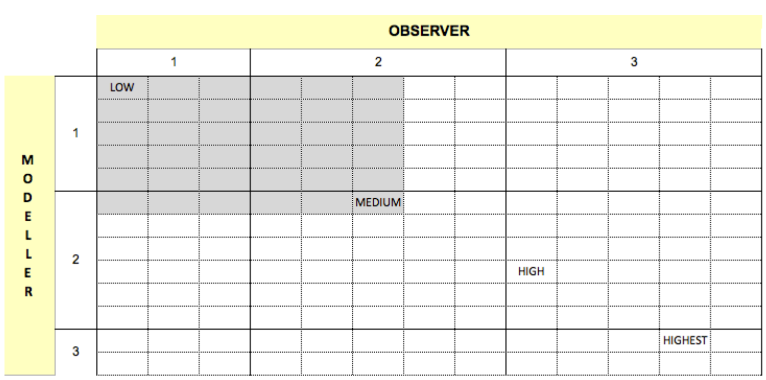

Figure 8 - Evolution Paths for Organisational Use of Information

The Modeller maturity levels (or capabilities) are presented in the matrix rows, whereas the Observer maturity levels (or capabilities) are presented in the matrix columns. Inside each level, the number of "steps" to achieve varies according to previously defined evolution of capabilities in Figure 7.

In that way, an Agent starting at the position (1, 1) in the matrix will gradually evolve its capabilities reaching progressively higher maturity levels of its Observer and Modeller Components. Each step of the evolution in its Observer component will increase a position vertically – on the columns –, and each step of the evolution in its Modeller component will increase a position horizontally – on the matrix rows –.

As an example, after having navigated along the evolution path over a given period of time, an Organisational Agent could find itself presenting a matrix like the one depicted in Figure 9.

We argue that in a given instant, distinct agents in a given organisation can be at different maturity levels, not being at the same "point" in the maturity evolution path.

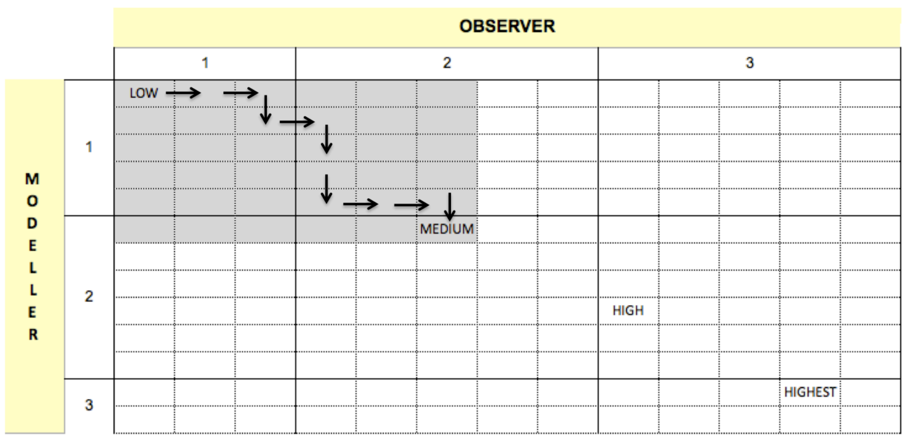

Figure 9 - Example of Maturity Evolution Path for Organisational Use of Information

5 Conclusions and Future Work

5.1 Conclusions

Accurate Maturity Assessment of Organisational use of Information reveals itself to be an intricate task, where a series of variables must simultaneously be taken into account. The generally recognized and massively used fixed-level maturity models are an oversimplification of the actual maturity levels existing in real-world organisations, and are unable to fully grasp organisational particularities.

To accurately assess maturity levels in our research domain of Organisational Use of Information, we applied the more realistic and customisable approach of Focus Area Maturity Models. In combination with the concepts of Control Theory and Feedback Loops, we were able to define unique agent characteristics and combinations of Observer, Modeller and Controller components, and built upon them in order to define realistic and most approximate near-reality evolution paths. Those evolution paths were presented in a model that allows for a better visualisation of current maturity level.

This overall vision of agents and their components allows for a further and simplified analysis of diverse real-life scenarios by cutting trough organisational complexity. Building upon those concepts, we are able to analyse agent maturity and grasp individual needs.

5.2 Main Contributions

This research main contribution is to provide a framework to assess Organisational Maturity in its daily use of information and define related maturity evolution paths, by abstracting enterprise complexity trough the use of an "Agent Decision-Making Feedback Loop".

Thanks to this "Feedback Loop" vision, the proposed model enables to determine individual information requirements and needs, Agent by Agent, and to define evolution paths – ultimately culminating in Business Intelligence –.

This research provided a more detailed awareness on how Organisations have to pilot trough their evolution paths, progressively and adequately gaining capacities and maturity in their information use.

5.3 Scope and Limitations

The proposed solution presents a major shortcoming: the lack of an accurate and methodological way of defining exact capabilities positioning in the Focus Area Maturity Model for Organisational Use of Information (Figure 7).

As described in Section 4 “Solution Design”, the position of the letters defining each component capabilities is determined by a thorough research and field study. The proposed definition of the letter positioning in this research was determined by our experience at *Moviflor*, and lacks of a more accurate and thorough theoretical foundation.

5.4 Future work

As previously described in the “Scope and Limitations” Section, a complete research and study is required in order to acquire new knowledge on Focus Area Maturity Models capabilities’ evolution, and to define precise Capabilities’ position in the matrix, as well as exact evolution steps between each progressively mature Capability in the Organisational Use of Information domain.

Additionally, some further research and reflections will be necessary in order to fully understand maturity evolution impacts on distinct Organisational Agents – from “Single-Agents” to more complex compositions of “All-Agents” –.

Maturity evolution in the domain of Information Use will most certainly have distinct impacts on distinct Agents, depending on Agent complexity and Organisational maturity:

- Which Agents will feel the bigger impact in case of malfunctions in their “Observer-Modeller-Controller” cycle?

- Which Agents will feel the bigger impact in case of maturity evolution in their “Observer”, “Modeller” and “Controller” components?

And also, which Agents will have a faster and sustained evolution of maturity, given the need to evolve?

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