Sustainability of Business Ecosystems for Next Generation Cognitive Networks

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Abstract—

This paper analyzes the viability and sustainability of business ecosystems for next generation self-growing, reconfigurable, and energy-aware networks. Focus is placed on how inter-actor relationships in business ecosystems can affect and act as barriers for commercial success of energy efficient solutions. For this, the paper combines a multi-actor framework (MACTOR) with a Business Model approach. The paper examines the business ecosystem of a new self-growing and energy efficient technology – CONSERN. The main actors, their balance of power, and convergence and divergence with respect to strategic positions are analyzed and visualized using the MACTOR framework. From this, implications for key actors, their relationships and the viability of the business ecosystem are derived.

Keywords - business ecosystems; business models; MACTOR; energy efficiency; self-growing systems.

I. INTRODUCTION

Smarter devices, intelligent networks and efficient service models are changing the way people communicate with each other. The vision of an autonomous, energy-aware and intelligent control, configuration and delivery mechanism has brought a radical paradigm shift in the way wireless networks are designed and deployed. Today, wireless solutions are mostly deployed and optimized to be purpose-specific, lacking required flexibility and autonomicity to operate seamlessly with neighboring network infrastructures. It is critical for both small-scale and large-scale networks to be flexible and interoperable, enabling them to serve different purposes at the same time. A promising path in the direction lies in the study and development of energy-aware distributed and self-growing cognitive systems based on wireless sensor networks, which are aimed at monitoring and control purposes.

Furthermore, networking solutions, when equipped with functionalities like self-growing, energy awareness, reconfigurability and autonomicity, can effectively alleviate the overall energy consumption and emission footprint of entire infrastructure. They are not only beneficial for the global environment but also enhance the business proposition for the network operators and infrastructure owners supporting sustainable and profitable business. However, there exists a research gap in our understanding of interactions among the actors comprising the business ecosystem, in particular, the ecosystem for next generation energy-efficient networking technologies.

This paper argues that the combination of multi-actor framework (MACTOR) with a Business Model approach can further our understanding of the viability and sustainability of business ecosystems for next generation self-growing, reconfigurable, and energy-aware networks. Such a combination will allow for (i) identifying the key technical and non-technical (business) actors and strategic objectives (issues) and (ii) examining the behavior of actors and their position on objectives (issues) using a conceptual framework.

The paper examines the business ecosystem a new self-growing and energy efficient technology – CONSERN. The EU ICT-FP7 STREP project CONSERN (COoperative aNd Self growing Energy awaRe Networks) intends to tackle the challenges posed by a heterogeneous wireless network by efficiently utilizing the reconfigurable wireless communication nodes and introducing cognitive control functionalities. The underlying aim is to develop and integrate a dedicated, purpose-driven wireless network characterized by a service-centric evolutionary approach introduced as an energy-aware self-growing network and system. The business ecosystem of CONSERN consists of both technical and non-technical (business) actors, active under the influence of externalities capable of determining and delimiting the evolution and sustenance of the ecosystem. Therefore, it becomes important to assess the viability and sustainability of such an ecosystem where multiple actors, functionalities and a variety of objectives interact with each other.

The multi-actor (MACTOR) methodology is well suited for exploring inter-stakeholder relationships. It links the strategic objectives of each actor and its positions (on these objectives) to the actual configuration of the business model under study, allowing to differentiate between the synergies and divergences found for a particular business model and those identified for alternative commercial deployment modes, and thereby to evaluate which deployment model could be successful and which shows no ecosystem support. The Business Model Configuration Matrix developed in [11] provides a framework for such strategic design choices,

by phrasing its strategic objectives in terms of crucial control and value parameters, and considering stakeholders' positions on these objectives as the evaluation they make on these control and value design choices. Hence, the structured stakeholder opinion analysis of MACTOR can be complemented by the structured business model design choices provided by the BM Configuration Matrix.

By applying both methodologies, it will be possible: (i) to examine the business ecosystem from an actors' point of view, (ii) to identify issue-specific convergences and divergences of a actors relative to others, and, (iii) to link these to crucial design properties of the ecosystem under study (both in terms of control and value), while also contributing to the identification of (iv) actors that are instrumental for the sustainability of the ecosystem, and, (v) strategies for eliminating strong existing divergences that impede the market adoption of green wireless solutions.

The rest of this paper is structured as follows. Section II explores the concept of business ecosystems followed by the identification of key actors, roles and stakeholders needed to define an ecosystem. In Section III, we introduce the context of energy aware self-organizing wireless networks for which we outline a potential the business ecosystem, its key actors, roles and stakeholders. In Section IV, we adapt the MACTOR framework to the Business Model Matrix, and experimentally apply the multi-actor analysis to our chosen CONSERN business ecosystem and deployment, in order to identify main convergences and divergences in the ecosystem with respect to control and value references. Section V discusses the main results. Finally, Section 5 concludes the paper with and points out some directions for future research.

II. THE BUSINESS ECOSYSTEM

In the following section we discuss the key components used to define a business ecosystem:

A. Definitions

The term 'business ecosystem' was coined by James Moore [7] as:

"An economic community supported by a foundation of interacting organizations and individuals—the organisms of the business world. This economic community produces goods and services of value to customers, who are themselves members of the ecosystem. The member organizations also include suppliers, lead producers, competitors, and other stakeholders. Over time, they co-evolve their capabilities and roles, and tend to align themselves with the directions set by one or more central companies. Those companies holding leadership roles may change over time, but the function of ecosystem leader is valued by the community because it enables members to move toward shared visions to align their investments and to find mutually supportive roles."

For analytical simplicity, we adapt and apply the following definition of a business ecosystem: a network of business actors, which are inter-related and mutually dependent, the ecosystem being defined and delimited by its relation to an energy efficient technology – CONSERN. The overall strength and weakness of such a business ecosystem depends mainly on how each actor – both business and technical – contribute (adds value) to the ecosystem [11].

Actors are the entities that take up different business roles. Actors can be companies, individuals, groups of individuals, governments, etc. Relationships, within the ecosystem are interactions between the actors. These relationships co-evolve with actors and their roles over time, and are often influenced by the business environment and the specific moves made by the actors. In addition, actors differ in their objectives, their behavior and their criteria for decision-making. Based on their preferences and willingness to generate high returns, each actor may pursue different strategies with respect to the business ecosystems.

III. CONSERN : OVERVIEW AND ECOSYSTEM

Low energy and automated solutions can create an attractive business case by offering significant benefits in terms of operational cost, long-term product reliability, sustainability, and increased lifetime of wireless elements. A promising path lies in the development of energy-aware distributed and cooperating systems for monitoring and control, on wireless sensor networks. At the same time, as systems get more complex in terms of scale and functionality, reliability and dependability are getting increasingly important. Currently, wireless network development is driven by horizontal mass-markets ("one size fits all"). Vertical markets and niche applications demand for (costly) dedicated configurations or developments. Consequently, the evolution of a wireless network often demands for infrastructure and terminal replacement. Extending system and network capabilities, switching services or switching the purpose of an operational network usually requires costly (manual) reconfigurations and upgrades. As a summary, energy efficient and dependable operation at the level of cooperating wireless elements, and networks as a whole is becoming an increasingly difficult objective.

CONSERN was initiated to meet these requirements and tackle the challenges posed by heterogeneous wireless networks by introducing cognitive control functionalities. In the following section, we present a brief overview of CONSERN from a technological as well as business standpoint.

A. Technological Overview

CONSERN is developing a novel paradigm for dedicated, purpose-driven small-scale wireless networks characterized by a service-centric evolutionary approach – an energy-

aware self-growing network and system. Existing solutions that are optimized for a single-purpose are expensive and lack flexibility; flexibility would allow creating hybrid solutions without needing significant effort for incorporating additional network and service gateway functions in order to achieve interoperability.

Self-growing capabilities are enablers for a novel type of network flexibility. They allow optimising a heterogeneous collection of network nodes or sub-networks to be dedicated to a specific optimisation target ("purpose") temporarily and on-demand. From a technical perspective this approach relies on node and network reconfigurability for achieving adaptability to multiple applications. From a complementing business perspective this approach facilitates addressing multiple niche markets / vertical markets utilizing a single line of hardware/software developments.

CONSERN thus pursues an approach to increase dependability, cost and energy efficiency, and also flexibility, resilience, and robustness of a heterogeneous wireless network by utilizing reconfigurable wireless communication nodes and distributed cooperative control functions [5]. The key objectives of CONSERN include:

- Development and optimization of cooperative mechanisms for heterogeneous distributed elements in a small-scale, purpose-driven network,
- Provision of the fundamental underlying mechanisms that pave the way for scalable energy efficient heterogeneous self-growing network paradigms and outline the potential market impact of such paradigms.

Depending on the functionalities and requirements, CONSERN energy-aware self-growing paradigm can be deployed in various environments including construction sites, embedded incident areas, campuses, home/office and urban heterogeneous environments. For the purpose of our analysis and the development of the methodology, we chose an office scenario, as it includes a relatively limited set of stakeholders to perform the initial MACTOR analysis on, while it can at the same time easily be extrapolated to more complex campus-wide scenarios. Moreover, the home/office environment is the most referenced scenario in terms of the developed CONSERN technical use cases.

In terms of business models, several configurations can be considered in the Office scenario presented below: Operator-Centric strategies, Operator-Independent strategies, 3rd Party Provisioning etc.. The deployment configuration we chose to highlight in this paper is entirely Operator-Independent, i.e. an Infrastructure Owner plans to independently build and operate a CONSERN ecosystem, making use of off-the-shelf products and excluding any role for a Network Operator. The key motivation for choosing an Operator-Independent strategy is the fact that it explicitly captures the underlying objective of CONSERN to deliver significant and specific impact on home/SME/institutional end users that do not have the resources to set up complex networks and which are especially benefiting from power efficient, easily scalable solutions. However, a complete analysis would perform and compare a MACTOR/Matrix-based evaluation for several business model configurations.

B. Home/Office Environment

Figure 2 represents an office scenario where the CONSERN enabled network devices are deployed to realize a purpose-driven small-scale wireless ecosystem. The key functionalities addressed here include energy awareness, flexibility in deployment and improved reconfigurability along the lifetime of the network. In order to highlight these functionalities (and other value added aspects of CONSERN), we present two instantiations based on the lifecycle of a home/office ecosystem where an Infrastructure Owner (IO) decides to purchase CONSERN enabled networking devices from the market and deploys them independently for his and employees day-to-day business activities.

Phase I - addresses the flexibility of deployment and ease of purpose reconfigurability of CONSERN systems. In this case, a small equity management firm that have normal day to day requirements like communications, smart infrastructure management etc. To do this, the network administrator chooses to deploy CONSERN system – configuring the network to be more energy (and resource) efficient and equipped for day to day network operations. Doing so, the network manager limits of traditional key players such as network operators and service providers etc., in the deployment of the CONSERN enabled networking infrastructure. Still, it should be noted that a Broadband Operator (BO) provides the backhaul connection to the Internet and has default services bundled in the subscription. At the same time various 3rd Party Application Service Providers (ASPs) compete to deliver the applications to the End Users (EU) inside the office environment. Similarly, the Wireless Network Operator also provides wireless connectivity (like 3G, LTE etc.) to the end users, however it does not control the CONSERN system nor does it provide the backhaul capacity to it.

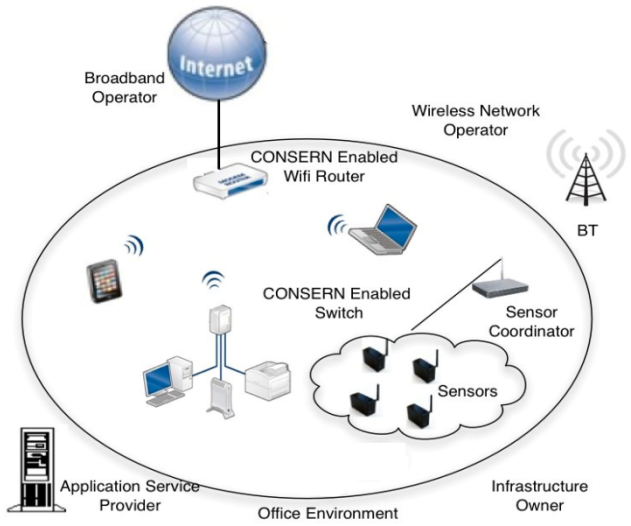

Figure 1: CONSERN Ecosystem (Phase I)

Phase II - addresses the reconfigurability aspect of CONSERN ecosystem throughout its lifecycle. After a few years of successful operations (of Phase I), the equity management firm is acquired by a multinational bank, which provides management and consulting advice to their clients in addition to other day-to-day operations. The security manager at the bank now realizes that the present CONSERN networking infrastructure which was until now used only for communication purposes, can be successfully reconfigured to a more secure and robust networking infrastructure for the day-to-day activities like cash transfers, bonds, exchange of sensitive information etc.

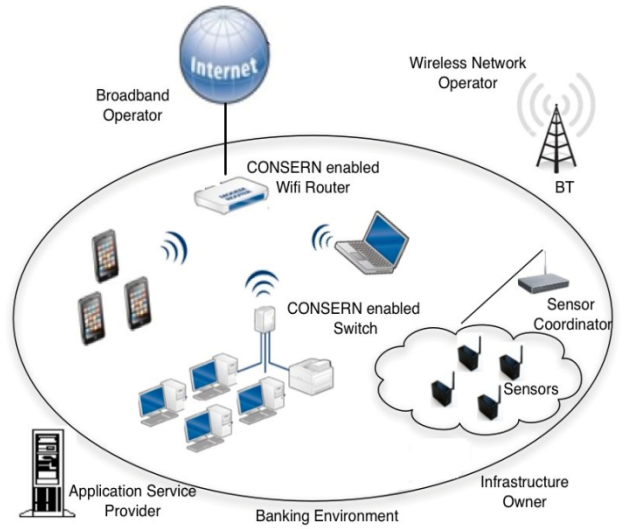

Figure 2: CONSERN Ecosystem (Phase II)

Figure 2 and Figure 3 provide an overview of the CONSERN ecosystem for the first half and second half of network lifecycle. Given below is a brief overview of business relationships between the focal actor (the infrastructure owner – IO) and other actors in this ecosystem:

1. The Infrastructure Owner purchases the CONSERN enabled devices from the Device Manufacturers (IO-DM).
2. Infrastructure Owner subscribes the network connectivity from the local Broadband Operator for his employees and residents (IO-BO).
3. Infrastructure Owner also subscribes to the Wireless Network Operator services for mobile connectivity (IO-WNO)
4. For applications like VoIP, Video Conferencing and IPTV etc., the Infrastructure Owner relies on various Application Service Providers (IO-ASP)
5. The End Users (EU) are the employees of the Infrastructure Owner; their key role is to contribute to the business proposition of that firm (IO-EU)

On the basis of the above two instantiations of the home-office ecosystem, the investment and operational costs of the Infrastructure Owner will decrease, and a range of services in various domains (like security, reliability etc.) will be enabled through the networks constructed using CONSERN technologies. This increased activity in both network and service deployment, and the added value generated by the End Users making use of CONSERN-enabled network technologies, will also have positive impacts on future business propositions and contributes to general sustainability.

IV. MULTI ACTOR ECOSYSTEM ANALYSIS

The MACTOR (Matrix of Alliances and Conflicts: Tactics, Objectives and Recommendations) method is based on actor interactions, and attempts to give an overview of alliances and antagonisms in a business ecosystem. The underlying aim of using MACTOR is to assist key actors and stakeholders in strategic decision-making that is related to potential co-operations and confrontations [1].

As explained (Section III), the business ecosystem of CONSERN consists of actors with different relationships and motivations. MACTOR allows to perform issue-level assessments as well as derive more abstract implications and recommendations on a higher level. The key steps for performing MACTOR analysis are explained in the form of a flowchart (see Figure 3) and implemented in details for the CONSERN business ecosystem.

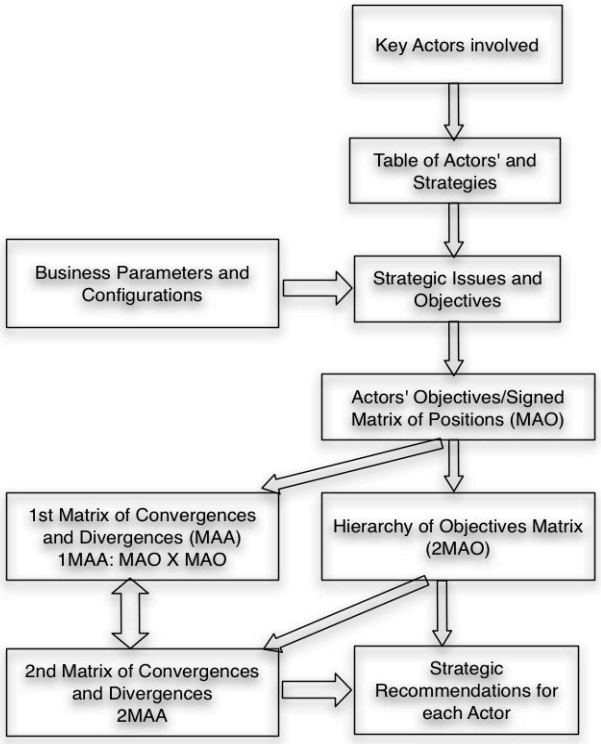

Figure 3: MACTOR Analysis based on Business Parameters
Source: Adapted from [1].

A. *Identifying Actors*

The first step is to identify the actors involved in the CONSERN business ecosystem. As mentioned in Section 3, the CONSERN business ecosystem consists of actors mainly from telecom industry and stakeholders like Infrastructure Owners and End Users. Since our exploration is limited to a home/office environment, this delimits the key actors defining the business ecosystem to the following:

Table 1 Identifying Actors

Actor	Roles based on Office Scenario
Broadband Operator (BO)	Responsible for providing backhaul connectivity.
Infrastructure Owner (IO)	An equity management firm, which is then acquired by a bank.
End User (EU)	The employee of the bank/equity firm.
Device Manufacturer (DM)	Manufactures and distributes the CONSERN enabled equipment to the clients.
3rd Party Application Service Provider (ASP)	Provides application services to the User/Buyer in competition with other ASPs. We assume the Broadband Operator provides default services along with the data subscription.
Wireless Network Operator (WNO)	Provides wireless connectivity (e.g. 3G, LTE etc.) to end-users. However it does not control the CONSERN system nor does it provide the backhaul capacity to it.

It is to be noted that there are also other business actors and stakeholders like Device Managers, Module Developers, Network Administrators etc., which have been left out of the discussion.

B. *Introducing Business and Strategic Objectives*

An important question is under what circumstances we may expect CONSERN to be commercially successful, i.e., whether the business ecosystem described (in Section III) is sustainable in a future marketplace. In general it can be stated that a business model is feasible if there is a strategic fit between its key design parameters[11]. An important step in this direction is therefore to derive and define key strategic objectives on the basis of the business parameters proposed in [11].

The business model ontology presented in [11], consists of four abstract layers in which the business models operate under the constraints of three design parameters in each layer. On the one hand, the ontology encapsulates the dimensions of value creation termed as Value Parameters and on the other hand it captures the functional and network design parameters termed as Control Parameters. As shown in Table **2**, the four layers comprise of:

1. The *value network layer* describes the architecture of actors and roles in the marketplace.
2. The *functional model layer* encapsulates the architecture of technical components in the ecosystem.
3. The *financial model layer* determines the financial wellbeing of the resulting ecosystem.
4. The *value proposition layer* provides a general outline of the future product or service.

The design parameters are identified in the business configuration matrix presented in Table **2**.

Table 2: Business Model Configuration Matrix

CONTROL PARAMETERS				**VALUE PARAMETERS**			
Value Network Parameters		**Functional Arch. Parameters**		**Financial Model Parameters**		**Value Configuration Parameters**	
Combination of Assets		Modularity		Cost (Sharing) Model		Positioning	
Concentrated	*Distributed*	*Modular*	*Integrated*	*Concentrated*	*Distributed*	*Complement*	*Substitute*
Vertical Integration		Distrib. of Intelligence		Revenue Model		User Involvement	
Integrated	*Disintegrated*	*Centralised*	*Distributed*	*Direct*	*Indirect*	*High*	*Low*
Customer Ownership		Interoperability		Revenue Sharing Model		Intended Value	
Direct	*Intermediated*	*Yes*	*No*	*Yes*	*No*	*Price/ Quality*	*Lock-in*

From Table **2**, we derived six principal issues which are expected to have direct or indirect impact on the actors operating in the CONSERN ecosystem.

Table **3**, summarizes the relationship between the derived strategic objectives and business parameters. .

Table 3 Deriving Strategic Objectives

Objective 1: Increase in Energy Efficiency	
Intended Value	*Intended Value: The basic attributes that the product or service possesses which constitute the intended value to be delivered to the customer.* Increase in Energy Efficiency relates to the reduction in the amount of energy required to provide services (communications, security etc.) and relative cost savings due to the deployment of CONSERN enabled devices.
Objective 2: Partly Substituting Solutions	
Positioning	*Positioning: The complementarity and substitutability between products and services, by among others, identifying the most relevant attributes of the product or service in question.* Partly Substituting Solutions relates to the fact that the CONSERN networks deployed by the IO at least partly substitute connectivity solutions offered by network operators. Instead of relying on these operators for in-building communications, the IO deploys its own network. In this scenario, the BO still provides the broadband backhaul link to the IO's system, and the WNO provides cellular connectivity outside of the premises, so the value proposition is also partly complementary..
Objective 3: Reduced Complexity	
Interoperability, Modularity, Distribution of Intelligence	*Interoperability: The ability of systems to directly exchange information and services with other systems.* *Modularity: The design of the systems as sets of discrete modules that connect to each other via predetermined interfaces* *Distribution of intelligence: The distribution of processing power, control and management of functionality across the system in order to deliver a specific application or service.* Reduced Complexity represents the overall flexibility of installation and operation of CONSERN systems. This objective also captures the key functionalities of CONSERN, i.e., the high interoperability and cooperativeness of CONSERN enabled devices with an existing ecosystem.
Objective 4: Independence from the Operator	
Customer Ownership, Combination of Assets, Vertical Integration	*Customer Ownership: Identifies which stakeholder assumes the direct commercial relationship with the customer.* *Combination of Assets: the resources that are available and useful in any activities an organization undertakes in pursuing its goals.* *Vertical Integration: Identifies if the underlying business model is vertically integrated or disintegrated.* Independence from the Operator refers to the instantiation where the Infrastructure Owner decides to setup his own CONSERN ecosystem independently. This implies that there is no customer relationship with an operator for this network, nor does the operator assume mangement responsiblities As three different networks are operational (BO, WNO and IO) which are partly connected to each other, and additional services are offered by ASPs, the combination of assets is distributed and the system is vertically disintegrated.
Objective 5: Reliance on non-proprietary devices	
Interoperability, Modularity, and Intended value	*Definitions (see above)* Non-Proprietary devices mainly refers to the scope of deploying off-the-shelf networking equipments from multiple vendors, as opposed to using integrated proprietary systems (which would be more likely in operator-centric or vendor-centric integrated scenarios, and of which the intended value would be to create customer lock-in). This also translates to the fact that multiple device manufacturers can compete constructively within the marketplace in order to sell their CONSERN enabled devices hence providing the Infastructure Owner multiple alternatives to choose from.
Objective 6: Revenue Model	
Revenue Model	*Revenue Model: The anticipated revenue generated and shared amongst the actors involved in the value network.* As OTS hardware is used and there is no customer relationship with an operator in this scenario (at least for what the operation of the CONSERN network is concerned, revenue flows directly to the device manufacturer instead of passing the operator (or alternative system integrators, service providers etc.).

C. Positions of Actors in relation to the Strategic Issues

Based on the instantiations described in Section 3, the position of each actor in the CONSERN business ecosystem is mapped into Matrices of Actors and Objectives (MAOs) on the basis of possible alliances/ conflicts and the hierarchy of objectives of actors. Therefore, we need to understand the position of each actor on a specific issue. To do this, we need examined each strategic objective and ranked each actor's convergence, divergence, or neutral stance as (+1, -1, 0) as well the level of opposition or agreement with the objective is high, medium or low (-3 to +3). In other words, the important the objective would be for an actor the higher the absolute value recorded. Note that, at this stage of research, this ranking of positions was made based on initial inputs and needs to be validated by stakeholders as a next step.

- Increase in **Energy Efficiency** is a key concern for all the actors directly related to and operating in the CONSERN ecosystem, except for the 3rd Party Application Service Provider because of its indirect relationship with the ecosystem. Therefore, we assume the preferences on energy efficiency as a priority and therefore ranked as (+1) on the 1MAO Matrix (see Table 4), whereas for a neutral stance, the ASP is awarded no rank. But it is to be noted that although all the actors (except ASP) converge on increase in energy efficiency the priority of the issue is lower for the Network Operators (BO, WNO) as the operators are not directly operating inside the CONSERN ecosystem, hence ranked (+1) in 2MAO (see Table 5) when compared to (+3) for the Infrastructure Owner.

- Providing **Partly Substituting Solutions** to the End Users is the key motivation for the Infrastructure Owner to deploy CONSERN in an office environment. This move by the Infrastructure Owner is against the interest of both Broadband and Wireless Network Operators, because for a Broadband Operator, CONSERN ecosystem will delimit its control over the wired infrastructure of the Infrastructure Owner. The Wireless Network Operator at the same time risks loosing the wireless connectivity provision and resulting revenues inside the End User ecosystem. The 2MAO matrix shows the seriousness of the issue as all the actors (except the End User) rank this issue as (±3) in their hierarchy of objectives.

- **Reduced Complexity** reflects the extent to which the complexity of network deployment for an Infrastructure Owner reduces throughout the network lifecycle. Reduced complexity in network deployments has an anticipated positive impact on all the actors and can accelerate their business objectives and competitiveness. Hence all the actors in the CONSERN ecosystem purely converge on this strategic objective, hence ranked (+1). But similar to the energy efficiency, this objective as well is of low priority (only +1 in 2MAO) for the Network Operators because of the non-involvement of NOs inside the CONSERN ecosystems.

- Independence from the Operator here reflects the limited role of Network Operators (wired/wireless) in the CONSERN ecosystem. Operator-Independent deployment strategies employed by the Infrastructure Owner will further narrow down the customer ownership of both Broadband Operators and Wireless Network Operators, thereby disintegrating the previously existing Operator-Centric vertically integrated business models and hence ranked (-1) for these actors. On the contrary, the 3rd Party Application Service Providers will be benefitted by operator independent ecosystem, as it provides a level playing field for the ASPs to compete and deliver services to the End User (+1) on MAO and (+3) on 2MAO.

-Flexibility of deploying **Non-Proprietary Devices** in the CONSERN ecosystem is derived from the Operator-Independent strategy employed the Infrastructure Owner to build the CONSERN ecosystem by himself. Independence in choosing a specific device manufacturer can be a strong motivation for the Infrastructure Owner to deploy CONSERN. For Network Operators integrating local access networks with their wider area systems using proprietary systems (developed in cooperation with selected vendors) is impossible in this OTS-based scenario, lowering their control (-1). Device Manufactures may choose to converge or diverge depending on their collaborations and tie-ups with the Network Operators.

- Revenue Model reflects the opportunities for sharing revenues between stakeholders. As in this instantiation the investment in CONSERN system components flows directly to Device Manufacturers, the Infrastructure Owner excludes Network Operators from the revenue stream both in terms of infrastructure provision and operational revenues. Similar to the Product Substitution the Revenue Sharing is also a high priority for all the actors (except for ASP and EU) hence this issue as (±3) in their hierarchy of objectives.

This ranking is summarized in the MAO and 2MAO Matrices shown in Table **4** and Table **5**. Σ+ and Σ- in the rows and columns presents an initial overview of those objectives which divide and unite the actors in the CONSERN ecosystem. For instance, the issue on Revenue sharing divides (±2) and involves (four opinions) from the actors, whereas the issue of Reduced Complexity and Energy Efficiency intrigues and unites a majority of actors in the ecosystem.

D. Formulate the Actor Interaction Matrix

The next step is to rank the issues for each actor, which is then used to formulate the Actor Interaction Matrix. To do this, we need to use the multiplication property [10] of matrix calculation, where by multiplying a matrix with its transpose yields a number of factors in common for each pair of lines in the original matrix. In our case the original matrix MAO (Actors X Objectives) when transposed yields MOA (Objectives X Actors). The product of MAO and MOA results in the matrix MAA (Actors X Actors).

MAO X MAO : MAA (Actor X Actor)

Table **6** represents the MAA matrix with actors mapped against actors, since actors' preferences related to a certain issue was mapped as described in previous subsection (see Table **4**) the resulting MAA matrix is made up of both positive and negative scalar products.

Table 4: MAO Signed Matrix of Positions (Actors X Objectives)

	Energy Efficiency	Substitution	Complexity	Independence	Non-Proprietary	Revenue	Σ +	Σ -
BO	+1	-1	+1	-1	-1	-1	+2	-4
IO	+1	+1	+1	+1	+1	+1	+6	0
EU	+1	0	+1	-1	0	0	+2	-1
DM	+1	+1	+1	0	0	+1	+4	0
ASP	0	+1	+1	+1	+1	0	+4	0
WNO	+1	-1	+1	-1	-1	-1	+2	-4
Σ +	+5	+3	+6	+2	+2	+2		
Σ -	0	-2	0	-3	-2	-2		

Table 5: 2MAO Importance of Objective for an Actor

	Energy Efficiency	Substitution	Complexity	Independence	Non-Proprietary	Revenue	Σ +	Σ -
BO	+1	-3	+1	-3	-3	-3	+2	-12
IO	+3	+3	+3	+1	+2	+3	+15	0
EU	+1	0	+1	-1	0	0	+2	-1
DM	+2	+3	+2	0	0	+3	+10	0
ASP	0	+3	+1	+3	+1	0	+8	0
WNO	+1	-3	+1	-3	-3	-3	+2	-12
Σ +	+8	+9	+9	+4	+3	+6		
Σ -	0	-6	0	-7	-6	-6		

The Matrix (MAA), therefore indicates the combination of each pair of actors and analyzes if they are in convergence or divergence. Each element in Table 7 and Table 8 is obtained by the matrix product, which retains only positive

and negative scalar products respectively. Each element (nCij) and (nDij) in the Matrix represents the number of objectives towards which actors i and j have a common convergence or divergence respectively.

Table 6: Actor-Actor Interaction Matrix (MAA)

	FNO	IO	EU	DM	ASP	WNO
FNO		-2	3	0	-2	6
IO	-2		1	4	4	-2
EU	3	1		2	0	3
DM	0	4	2		2	0
ASP	-2	4	0	2		-2
WNO	6	-2	3	0	-2	

Table 7: Convergence Matrix

	BO	IO	EU	DM	ASP	WNO
BO		0	3	0	0	6
IO	0		1	4	4	0
EU	3	1		2	0	3
DM	0	4	2		2	0
ASP	0	4	0	2		0
WNO	6	0	3	0	0	

Table 8: Divergence Matrix

	BO	IO	EU	DM	ASP	WNO
BO		-2	0	0	-2	0
IO	-2		0	0	0	-2
EU	0	0		0	0	0
DM	0	0	0		0	0
ASP	-2	0	0	0		-2
WNO	0	-2	0	0	-2	

E. Rank the Interplay Assessment

Based on the Convergence and Divergence Matrix in Table 7 and Table 8, we can draw two complete diagrams of convergences and divergences as shown in the and Figure **5**. The thickness of the connecting lines in the graph is proportionate to the number of issues converged or diverged upon.

F. Hierarchy of objectives

In order to accommodate each actor's specific hierarchy of objectives, we re-do the exercise and note the positioning of actors in relation to objectives on a scale from -3 to +3, according to whether the level of opposition or, agreement is high, medium or low. As a result we obtain a second valued matrix of position 2MAO (similar to 1MAO); by multiplying it by its transposed form we obtain a second MAA-type matrix, called 2MAA.

We can thus construct a second version of the complete diagrams of convergences and divergences, which does not differ noticeably from the first (which is why these second diagrams are not presented here).

Table 9: Actor-Actor Interaction Matrix (2MAA)

	FNO	IO	EU	DM	ASP	WNO
FNO		-21	5	-14	-20	38
IO	-21		5	30	17	-21
EU	5	5		4	-2	5
DM	-14	30	4		11	-14
ASP	-20	17	-2	11		-20
WNO	38	-21	5	-14	-20	

Table 10: Convergence Matrix

	BO	IO	EU	DM	ASP	WNO
BO		0	5	0	0	38
IO	0		5	30	17	0
EU	5	5		4	0	5
DM	0	30	4		11	0
ASP	0	17	0	11		0
WNO	38	0	5	0	0	

Table 11: Divergence Matrix

	BO	IO	EU	DM	ASP	WNO
BO		-21	0	-14	-20	0
IO	-21		0	0	0	-21
EU	0	0		0	0	0
DM	-14	0	0		0	-14
ASP	-20	0	-2	0		-20
WNO	0	-21	0	-14	-20	

V. INITIAL RESULTS AND DISCUSSION

The initial results of using the MACTOR/Matrix framework are presented in the and Figure **5**.

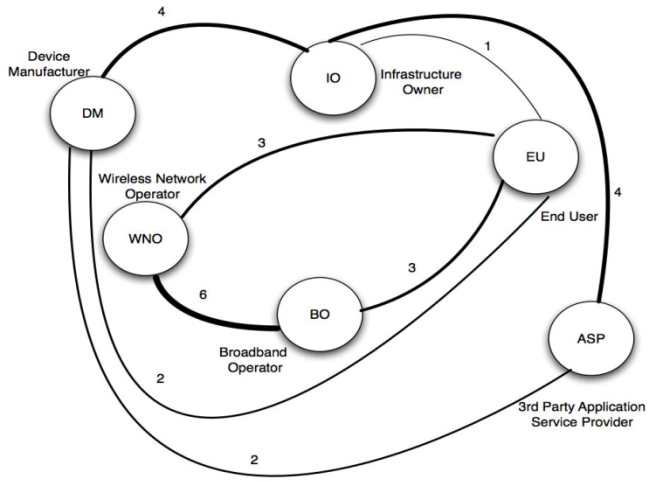

Figure 4: First Complete Diagram of Convergences over Objectives

Based on the convergence diagram represented in the following direct conclusions can be derived:

1) There is a quite high degree of synergy between the Infrastructure Owner, 3rd Party ASP and the Device Manufacturer (DM) since, in absence of a key role played by Network Operators, both ASPs and Device Manufacturers

can interact freely and directly with the Infrastructure Owner (for revenue sharing and service delivery).

2) The potential synergies between the End User (EU), the Broadband Operator (BO) and the Wireless Network Operator (WNO) are inhibited by the mediation of the Infrastructure Owner (IO) – who interferes with the existing operator-customer relationship by deploying and managing the CONSERN network all by himself.

On the other hand, Figure **5** represents the Divergence graph, where the Network Operators (BO, WNO) and Infrastructure Owner (IO) are in clear divergence with each other: firstly, because of the Operator-Independent strategy employed by the Infrastructure Owner and secondly because of the direct interaction between the Infrastructure Owner and the Device Manufacturer, which in more Operator-Centric models was mediated and managed by the Network Operator.

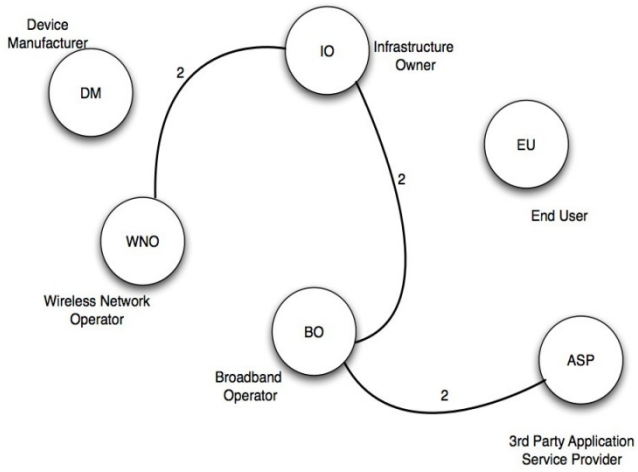

Figure 5: First Complete Diagram of Divergences over Objectives

Since the focus of our analysis is on Operator-Independent strategies, adopting Operator-Centric or 3rd Party-Centric deployment strategies can yield entirely different sets of convergences and divergences amongst the actors. Cross comparison of these actor-specific behaviors in an energy efficient ecosystem following Operator-Centric, Operator-Independent and 3rd Party deployment strategies can be seen as possible next steps for our work.

The IO's role within the network-centric group of actors: The infrastructure owner in an Operator-independent strategy of CONSERN deployment will direct confrontations and disagreements with the operators both wireless and broadband operators. In the following we provide a snapshot of inter-actor relationships developing in a CONSERN business ecosystem:

1) IO can directly interact with DMs inorder to purchase the legacy and CONSERN enabled devices (previously the network operator performed the role of purchasing and pricing).

2) 3rd Party Application Service Providers will find this opportunity beneficial for improving and re-inventing their present value of service offerings and closely collaborate with IOs (previously ASPs were dependent on the operators for service provisioning)

3) IOs can mediate the interaction between the end users and the ASPs both in terms of network and revenue sharing (thereby eliminating the presence of network operators)

4) IOs will be more independent and selective in choosing the dataplans and mobile connectivity from WNO and BO.

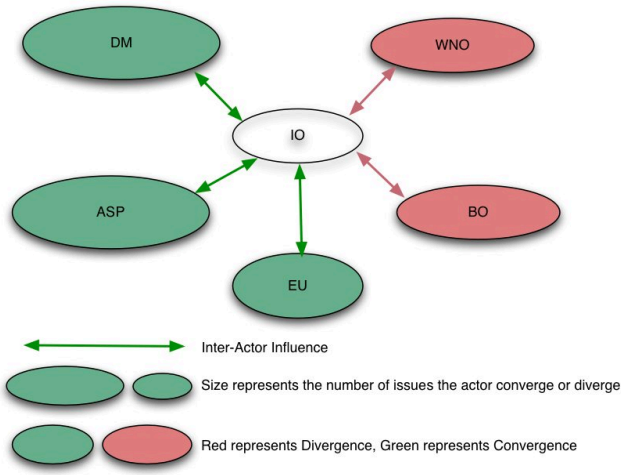

Figure 6: Relationship of IO & other actors

The BO's role within the network-centric group of actors: In the current telecommunications environment, operators, ASPs and 3rd Parties are direct competitors. In the following we provide a snapshot of inter-actor relationships developing in a CONSERN business ecosystem:

1) Once an Operator-Independent strategy is employed by the IO, the network operators (BO) will find themselves secluded off the mainstream access to the network as well as the revenues both from end users and ASPs.

2) BO and WNO (broadband and wireless network operators) will have similar impacts against the increasing willingness to cooperate between ASPs and IOs.

3) Some DM may choose to stay along with network operators in order to maintain a long term relationship with the operators in other streams of network deployment.

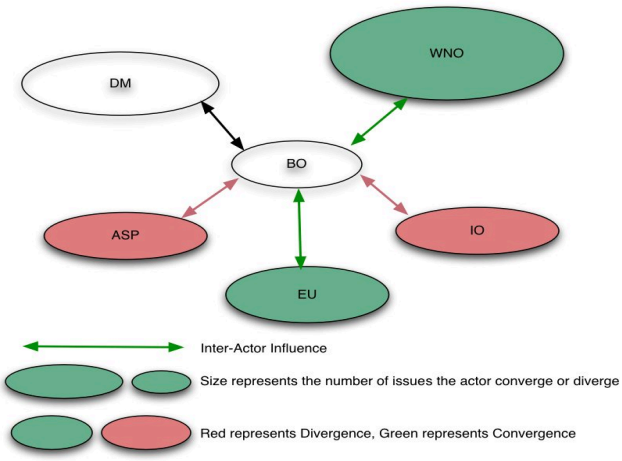

Figure 7: Relationship of BO & other actors

VI. CONCLUSION AND FURTHER RESEARCH

This paper addressed the viability and sustainability of business ecosystems for energy efficient cognitive networking technologies as they are currently being developed within the EU FP7 project CONSERN. We adapted and applied a multi-actor framework for assessing the interplay of actors in a business ecosystem, aimed at key issues like network automation, flexibility in deployment and reconfigurability over the lifetime of a network. We elaborated the business ecosystem of a home/office scenario and applied MACTOR to identify key strategic objectives that can essentially capture the viability of CONSERN enabled devices in the marketplace.

Using MACTOR allows us to formulate the strategic issues where various actors in the business ecosystem are in convergence, in divergence, or prefer to take a neutral stance. That said, although MACTOR is a an efficient tool for analyzing stakeholder positions towards specific objectives, it needed to be complemented with the Business Model Matrix to be able to deepen our insight on what these positions actually mean in terms of business ecosystem dynamics. Linking these strategic objectives and positions to the actual configuration of the business model under study allowed us to differentiate between the synergies and derive a potential set of best practices/recommendations for the actors.

While this exercise demonstrated the relevance of using multi-actor analysis for understanding the critical interplay between various stakeholders in a business ecosystem, there is still future research needed to validate our analysis. This includes:

- Exploring and establishing the CONSERN business ecosystem based on the inputs from real-world actors.
- Validating the stakeholder positions through expert interview sessions and workshops.

Nevertheless, our preliminary findings indicate that there exist substantial divergences for the development and realization of cognitive networking solutions for cost effective energy efficient systems. Multi-actor analysis, can the be collaboratively used amongst the stakeholders to specifically point out the divergences and misplaced incentives, hence ensuring an important step towards a designing mutually converged and economically sustainable business ecosystems.

ACKNOWLEDGMENT

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