Dynamic Knowledge and Healthcare Knowledge Ecosystems

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Abstract: The concept of Knowledge Ecosystem (KE) is used to define a community of practice that builds knowledge in a bottom-up, networked and dynamic fashion. These features define a new kind of digital ecosystem that is domain specific and operate in an open (virtual or real) world. The openness is an ideal situation that needs to apply the unified standards, for instance the Semantic Web Standards and Rules and Web 3.0 that help the building, growth, sharing and forgetting of knowledge across the Knowledge Ecosystems.

What makes the KE different from the "classic" view upon the digital ecosystem is an *active and dynamic process* that involves:

- the creation of knowledge;
- the intentional elicitation of knowledge;
- the ability of share knowledge across the entities; and
- the possibility to depreciate and forget knowledge.

How does the dynamic nature of knowledge influence the nature of knowledge ecosystems? What are the general principles that can be applied to design the sound and enduring knowledge ecosystems? These are some of the questions will try to get answers in our paper work.

First of all, we will show that the dynamic evolution of knowledge and the dynamic character of the flows of knowledge are essential for the transition from digital ecosystems to knowledge ecosystems. Having a static collection of pieces of knowledge, processing them and placing them in a digital ecosystem are not really enough for this one to becomes a knowledge ecosystem. *Continuous knowledge creation* is responsible for transforming the digital ecosystem in a knowledge one. The process of dynamic knowledge building occurs when internal (tacit) knowledge becomes external (explicit). The continuously feedbacks that operate between internal and external knowledge are producing new knowledge among entities and create the *energy and permanent innovation* that characterizes a knowledge ecosystem.

In the second part of the paper we have draw some general principles of accelerating the appearance of new knowledge ecosystems, while in the third section we define the main features of the knowledge healthcare ecosystem design for the home rehabilitation of people with motor disabilities. In order to do so, we are going to extract from these general principles the specific in-rules that make the agents involved in home health rehabilitation act as a knowledge ecosystem. Alongside the theoretical approach to our paper (that refers to the principles' establishing), there is also the practical one.
We conclude the paper work with some remarks on the KE's role and importance in healthcare, and in particular in home rehabilitation field.

Keywords: digital ecosystem, healthcare knowledge ecosystem, dynamic knowledge, flows of knowledge, home health rehabilitation, virtual network for home health rehabilitation.

1. The "journey" to Knowledge Ecosystems

In general terms, an *Ecosystem* is a system whose members benefit from each other's participation through symbiotic relationships. Within an ecosystem, there are thousands of organisms that live in a constant relationship with their environment, in the same time, relationships also developing among them. These relationships can be positive or negative depending on the type of objective/need assumed by each member of the ecosystem. A *negative relationship* (predation of parasitism) happens when one of the organisms gets the bigger share of the benefit in the relationship, that is to say, the association is destructive for one of its members.

Among the *positive relationships* we find symbiosis (or mutualism) that is a positive association between two or more organisms which results in a mutual benefit and sometimes, even fusion. According to biology experts, symbiosis has been the key in the natural evolution, since cooperation is fundamental to achieve integral participation, good results and ultimately, species' survival.

Similar with nature's ecosystem, the *Business Ecosystem* (BE) is a network of co-existing elements that depend on each other in order to survive. Today, every company is part of this BE working together with many other elements into a very complex system. In order to carry out its day-to-day business, a company

supplies its particular products and services, and relies on various products and services from other companies within the BE. In this way it builds the complex maze of interlinked elements of the BE.

The success of a company in the BE depends on its ability to find the right partners, manage these relationships, and ultimately extend the reach of its particular products and services.

But, to operate effective across the BE, companies are increasingly adopting Internet technologies. Business communication are supported by e-mails, companies are recognizing the opportunities offered by e-Commerce and use it to offer their products and services online, and they are carrying out e-Business more and more, transacting with partners via the Internet.

The companies positioned at the leading edge are using today the *Digital Business Ecosystem* (DBE). So what is a DBE?

Let us first to observe that we talk about a combination between Digital Ecosystems (DE) and the business world. The DE it is a *digital environment* populated by digital species (software components, applications, online services, information, business models, etc.).

Applying this concept in the economic field we obtain the DBE paradigm, i.e. a special Internet-based environment in which businesses can interact with each other in effective and efficient ways. Being part of the DBE means that a company is aware of the range of products and services available from all of the other partners and can easily match them with its business requirements. An the same time, its products and services are also being showcased to other companies so they can identify it as a potential business partner.

The DBE brings together the best of all of the Internet technologies, tools and applications as well as legal, business and revenue information that the companies need to have the competitive edge in the market. The main benefits of the DBE for the companies are (http://www.digital-ecosystem.org/):

- They *can manage their business more efficiently*. The company can manage business processes and communicate with other companies, as well as keep abreast of the latest opportunities, in an environment that is customized specifically for their particularities.
- With the DBE every business *can enjoy greater choice*, matching its requirements with a broader range of suppliers than it would otherwise have been aware of.
- The DBE *enables the automatic extend of the market reach*, one company's products and services being visible to a larger audience.
- The DBE *enables the easy combination of the services with those of other companies*, so they can build new products and services and fill additional market niches.
- *Companies can easily and effectively expand their own business*. As their range of products and services expands, it is constantly being showcased to all of the other partners across the DBE, so they, in turn, attract new clients.
- The DBE *enables companies to access information that they need in order to operate successfully*. It offers accurate and reliable, legal, financial and administrative information needed to operate on a day-to-day basis and maximize the business opportunities.
- As an online environment, *the DBE is always up-to-date*. As it expands, the latest information, software, tools, products and services made available by partners are constantly being added and shared to each company via the latest technology.

These advantages depict the DBE as an all-encompassing environment. With the latest technology, information and business tools, the companies can leverage the best possible solutions from Internet technology to expand their business.

The DBE is based on the concept of *communities*. These communities are built around different factors such as, *geographical regions, languages* and *industry sectors*. As the DBE expands and proliferates, and so do the communities. The latest list of communities is managed on the Web site and will bring a business to what is known as a "*knowledge platform*". From this knowledge platform, a company can also access the latest news, forums, contact details and knowledge for its community.

From the organizational perspective, a DE is based on *self-organization* and *biological evolution*. The *self-organization implies* intelligent behaviour and the ability to learn on a short time scale, whereas *evolution implies* the system's ability to optimize itself through differentiation and selection of its components on a long

time scale. These characteristics can be realized only if the ecosystem, as a whole, is able to learn over time and adapt to the *knowledge* produced by it as well as to the *knowledge* that it is derived from its environment.

Both types of knowledge *flow dynamically* among the entities within the ecosystem, leading to a new type of DE, the *Knowledge Ecosystem*. The KE definition in Wikipedia (an ecosystem that "fosters the dynamic evolution of knowledge interactions between entities") emphasizes on *dynamic character of knowledge into the ecosystems*. Processing a static collection of pieces of knowledge and placing them in a DE are far insufficient for this DE to become a KE. *Continuous knowledge creation* is what transforms the DE into a knowledge one. The process of dynamic knowledge creation occurs when *internal knowledge* is made *external*.

The feedback that operates between internal and external knowledge, continually effecting new knowledge among entities, creates the energy and permanent innovation that characterizes a KE. What makes the knowledge ecosystem different from the classic DE is an *active and general process involving (1) the creation of knowledge, (2) the intentional elicitation of knowledge, (3) the ability of share knowledge across the entities* and *(4) the possibility to depreciate and forget knowledge*.

2. Designing a KE – general principles

The existence of knowledge ecosystem is related with a Community of Practice (CoP) that builds knowledge in a bottom-up, networked and dynamic fashion. These features define a new kind of digital ecosystem that is *domain specific* and *operate in an open (virtual or real) world*.

"CoP" is a term that refers to the ways in which people naturally work together. It acknowledges and celebrates the power of informal communities of peers, their creativity and resourcefulness in solving problems, and inventing better, easier ways to meet their commitments.

In the real world of organizations, core competences do not reside in the abstractions of management theories; they reside and grow in CoPs. These communities can help organizations to:

- organize work in ways that makes people grow and be happy;
- accelerate business cycles;
- learn faster than the competition.

The CoPs deliver their value proposition by (http://www.co-i-l.com/coil/knowledge-garden/dkescop/kmo.shtml):

- Developing and spreading best practices faster;
- Connecting "islands of knowledge" into self-organizing, knowledge sharing networks of professional communities;
- Feeding and being fed by web-based repositories of proven solutions and new approaches;
- Fostering cross-functional and cross-divisional collaboration;
- Increasing companies' members' ability to initiate and contribute to projects across organizational boundaries.

In order to extract and understand the principles which the designing of the KE relies on, we will first discuss this concept from few different angles.

1. From a dual perspective, a KE consists in a) a network of *conversations*, face-to-face and electronic meetings, facilitated by results, richly hyperlinked with, feeding, and fed by b) *knowledge repositories* of what, who, why, how, where, and when.

CoPs co-evolve with their shared knowledge basis (a relatively *static* component), and the protocols and tools for upgrading it. But the *dynamic force of this co-evolution* is the *network of conversations*, in which critical perspectives, new needs and circumstances, and better solutions and practices to meet them, are introduced (see Figure 1).

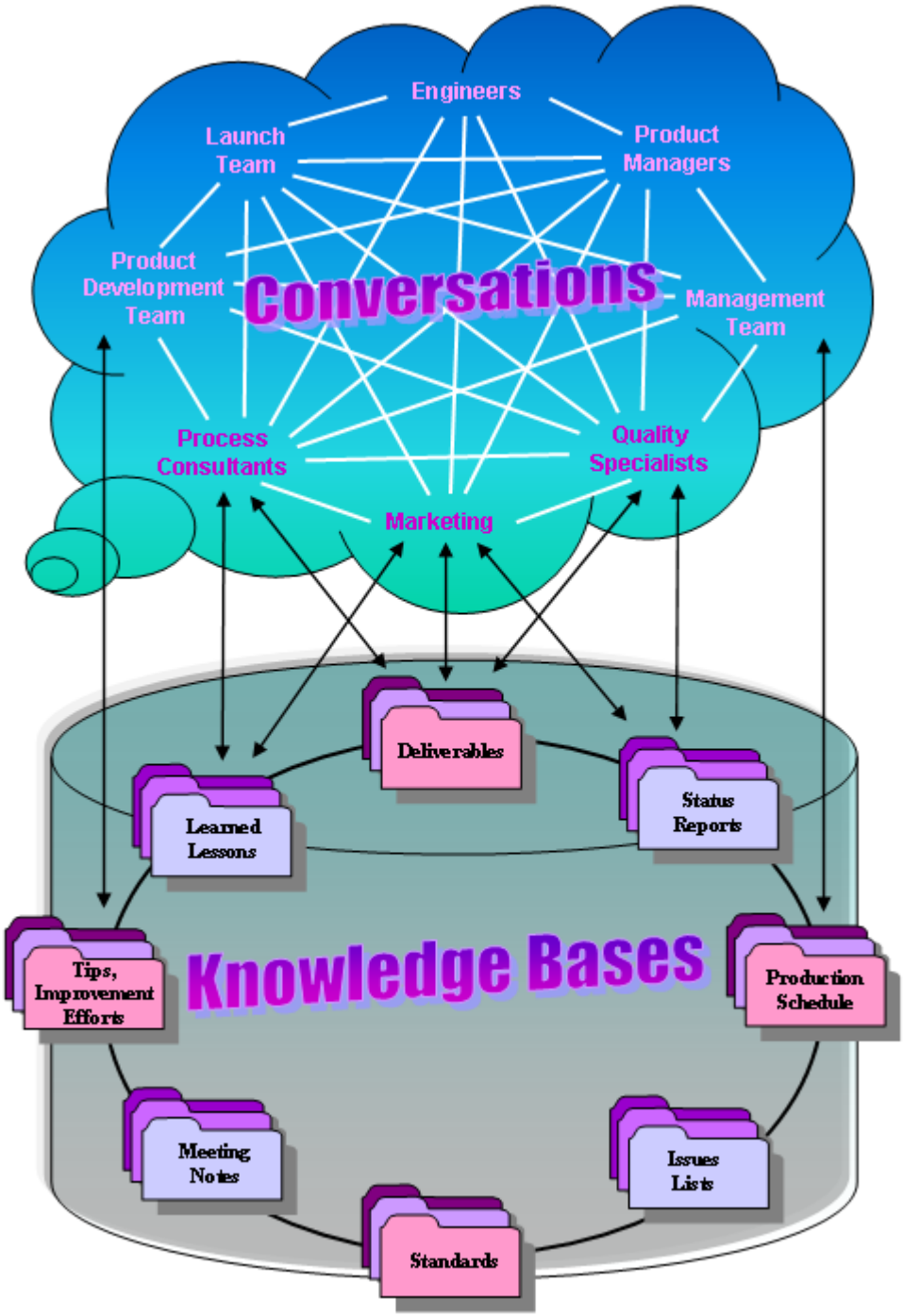

Figure 1: Duality knowledge – conversation (adaptation yin/yang diagram (Pór 2000))

2. From another perspective, KE can be seen as an interaction of *people, knowledge* and *technology* (Figure 2).

Facilitated by this interaction, the dynamic and continue action of the KE's members (augmented by the intelligence of the whole ecosystem) generates *social and business value*.

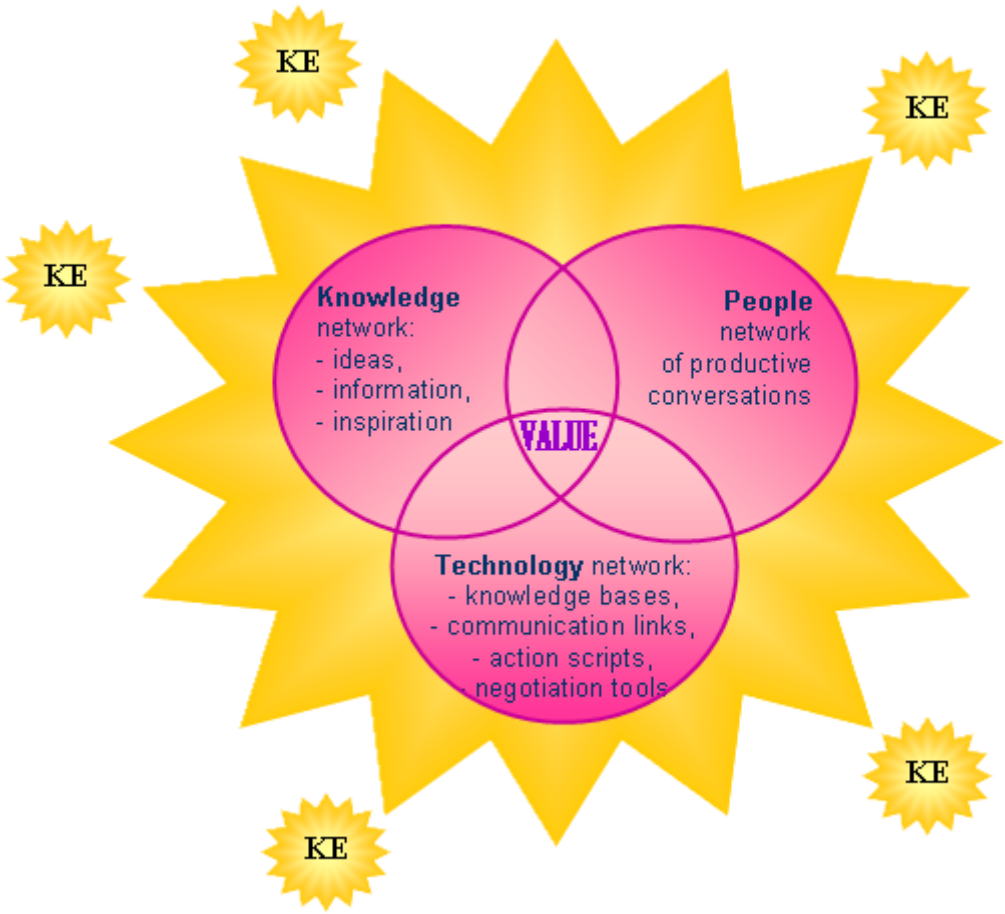

Figure 2: KE as a people, knowledge, and technology union

3. Finally, a KE is also a *complex adaptive system* of *human communities* co-located in the same physical and/or virtual space, in which they develop *relationships,* tools, and practices for creating, integrating, sharing, and using (also depreciating and forgetting) *knowledge*.

Although they are an extension of KM ideas, the design of KE is based on some principles that could seem contradictory with the theory and practice of KM.

As an example, from the KE perspective, knowledge cannot and should not be managed. Knowledge is a capacity of people and communities, continuously generated and renewed in their conversation, to meet new challenges and opportunities. It is not a „thing" that can be „managed".

Therefore, people responsible for knowledge value creation can only be inspired and supported, but they cannot be "managed" as people were managed in the industrial era. In this context, in order to support the valuable knowledge creation, organizations obsessed with extracting and measuring knowledge must shift the focus of their knowledge initiatives to developing an *open culture of communication and collaboration that is supportive to the sharing of innovative work and business practices*. This is the very essence and also the prerequisite of the existence of a Knowledge Ecosystem.

Another condition for the existence of KEs is to prepare the ground for these systems to emerge. This means to *facilitate the dynamic mixing of the Knowledge Ecology's "ingredients"*: CoPs, Management Strategy (including KM), Complex Adaptive Systems, and Digital Technology. Only then, the organizations could take the learning journey from *data* to *knowledge*, and possibly to *wisdom* (Figure 3).

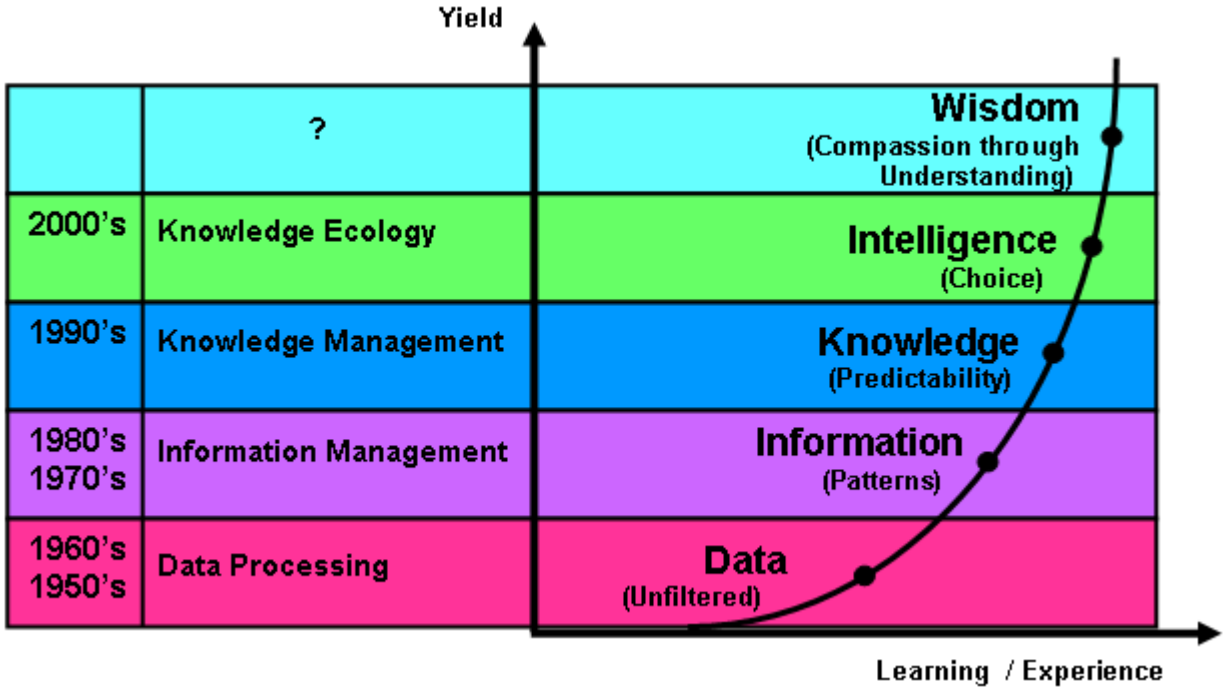

Figure 3: The "Data to Wisdom" Curve (Pór 2000)

As we have shown in the previous section, what turns a DE into a KE is the continue *dynamic feedback process* of knowledge creation and transformation, generated when internal (tacit) knowledge becomes external (explicit) knowledge and the latter augments and enriches the former. In fact, the dynamic nature of knowledge (flows) generates the principles that can be applied to design KEs. We summarize below some of these principles:

1. A KE exists within a supportive and stimulative learning environment that allows and encourages innovation and discovery, open communication and knowledge sharing as cultural norms. If the KM provides actionable information and opportunity, the KEs add the synergy and trust necessary to use information, recognize opportunity, and turn them into knowledge and action.
2. The KEs evolve and flow as knowledge itself does. The KEs are dynamic and energetic just as knowledge itself is a dynamic force for innovation and creativity. Within a KE the emphasis is not on knowledge objects, intellectual asset protection and leveraging; it is on culture, knowledge gardening, soft systems, pattern recognition, prototyping, continuous knowledge creation, sharing and use.
3. Within a KE, to benefit from the opportunities for assessing, organizing, and portraying knowledge is not enough anymore. A KE is community-oriented; it allows to its members to see what it takes to grow and sustain networks of relationships, from which knowledge will emerge. It focuses on dialog about the policy so as to ensure all organization members agree on the interpretations, developing alignment but do not insist on control.
4. The KEs' role is fulfilled if knowledge stores have quality criteria. Knowledge repositories must be kept up-to-date, accessible and coded in such a manner as to allow seamless and intuitive accessibility. Knowledge is dynamic, constantly changing, evolving and perishable; therefore KEs must be robust and flexible enough to take frequent updates, and also to allow the mechanism to "forget" the perishable knowledge.
5. Sometimes the technology has limitations that can thwart frequent change and reduce flexibility of knowledge ecosystems. A viable and useful knowledge ecosystem will reflect the understanding that knowledge is not static, and permanently new information will need to be codified and added to the KE repositories. In this respect, the entire "life" of the KE must be supported by the appropriate technology.
6. KE's existence is based on *processes* (conversations, tacit – explicit knowledge transformation, knowledge creation and use), *and things / agents* (people, knowledge repositories, technology). Although technological platforms can assist with communication and knowledge storage and transfer, *knowledge is created and used by the people*. Therefore, the active side of the KE has to do with *intellectual energy*; it is "relationships" focused: knowledge creation, meaning, belief, trust, dialogue, opinion, innovation, creativity. The human component of a KE must then be able and skilled to:
    - work together and share a mutual understanding;

- grow intellectually through knowledge exchange;
- put mutual benefits above the individual benefit, and understand that everyone will be better off if they act in this way.

Are these principles valid regardless the particular domain where the KE exists or need to be created? Are they exhaustive? Could they be applied as they were stated or do necessary transformations have to be made in order to adapt to the specific domains? One thing is for sure: we do not have answers to all these questions. But we will try to get some for the healthcare sector in the following section.

3. Knowledge ecosystems in healthcare

In order to understand how the concept of KE can be used in healthcare, we think that it is useful to introduce first the concept of *Healthcare Ecosystem* (HE). Let's start by observing that the healthcare market is one of the most complex ones, a huge diversity of „agents" co-existing here:

- organizations (hospitals, medical equipment suppliers, drugs suppliers, food and linen suppliers, specialized cleaning and sterilizing suppliers, logistics and IT companies);
- people (doctors, nurses, administrative personnel, patients and their family, pharmacists, IT specialists);
- medical practices, protocols and rules, (medical, IT&C) technologies, standards, regulations.

This multitude of agents activates within two functional structures: the *healthcare supply chain* and the *clinical chain* (Rivard-Royer et al. 2003).

The *healthcare supply chain* consists in the interaction of:

- vendors for the main row materials used in medical equipment and products manufacturing;
- manufacturers of various products (some of them may wish to interact directly with healthcare facilities in order to be aware of their specific needs);
- distributors that can play different roles within the supply chain: delivering a wide variety of products to each healthcare facility and even detain exclusive rights for a line of products from a particular manufacturer;
- group purchasing organizations, which are present on some markets (in the US, for example, where 70% of all major hospitals use such organizations (Rivard-Royer et al. 2003)), having the role to consolidate the purchasing power of their customers;
- hospital internal chain that process (receiving, storage, replenishment) the supplies before they reach the final destination (healthcare professional or patients);
- IT tools and logistical practices in a wide variety.

Alongside with all these components, the most distinctive characteristic of the healthcare supply chain is its dependency on the point of care (POC), which is the consumption driver in the clinical chain.

In essence, the *clinical chain* is a collection of medical and clinically related activities supporting the healthcare continuum (prevention – diagnosis – treatment - recovery)". These activities can occur in what we call the point of care, i.e. the place where the patient and the healthcare professional interact (operating rooms, hospital wards, outpatient clinics, doctors' offices, and lately patients' home or workplaces).

The integration of the supply chain and clinical chain, especially nowadays when homecare practices extract the POC and move it in non-conventional places, exceeds by far the possibility of current managerial and organizational practices to adequately support the POC in order to deliver a proper treatment. A lot of specific information regarding clinical needs and feedback following the consumption of supplies has to be added: lists of medical procedures (including surgery), patient admissions, discharge/transfers and planned patient care such as dialysis or homecare services (Rickles 1999). On the other hand, the continuity of care requires up-to-date information regarding the patient's past and current diagnosis and treatment (including laboratory results), pharmaceutical and administrative profile (insurance coverage). Technologies and practices are emerging to facilitate (under the legal frame) the efficient exchange of clinical and administrative information. Integrating this type of relevant information will enable supply chain cycles to be better synchronized with the real-time needs of the clinical chain in an economically feasible context.

The „structure" aroused from the integration of the supply and clinical chains, in which the driving role belongs to the clinical component, is a *Healthcare Ecosystem* (HE). Probably more so than any other market, healthcare operates in a true ecosystem. As long as these ecosystems are established on *protected*

information sharing to ensure that a patient receives the best treatment possible in the most efficient and timely manner, they are the true solution for the actual stage of the healthcare evolution. In a HE, the conflicts between the objectives and agendas of distinct entities within the system (that at times cause delays, inefficiencies and even errors in delivering healthcare services to patients) tends to be solved. Virtually, creating an *effective* HE requires the stakeholders to design an environment where all of the participants in the healthcare process benefit from each other's efforts, including the patients (or especially them).

What does it take to a HE to become a *Healthcare Knowledge Ecosystem* (HKE)? First of all, it has to be organized as a digital system, i.e. to benefit utmost from the advantages that virtual communications via Internet has to offer. Secondly, it has to be designed as an environment that augments the dynamic process of knowledge' creation, sharing, use, depreciation and forgetting. These characteristics are obviously necessary when we talk about home healthcare. In this particular medical area, the continuous flow of knowledge between medical staff, patients (including their family members), suppliers of medical equipments and products, and IT specialists is the core of the entire "construction". We will particularize some of the principles of the KE design for home rehabilitation after we introduce a few examples of KE in healthcare.

3.1 Examples of ecosystems in healthcare

These examples of KEs represent instances where web technologies help facilitate the flows of insights and knowledge, with unprecedented levels of volume, speed, and accessibility. However, we have to remark that the technology is not the main aspect within a KE; the process of knowledge creation is *human-centric*, and even with technology, there is so much we humans can know, learn, mentally absorb, and incorporate into a broader vision about our world and life.

An example of HE is *Continua*, an interoperable Personal Healthcare Ecosystem developed by an international alliance of more than 133 companies, Continua Health Alliance. *Continua* aims to enable the alignment of different vendors and domains, focusing on (Carroll 2007):

- *disease management*: managing a chronic disease outside of a clinical setting;
- *aging independently*: using technology and services to live in own homes longer, and
- *health and fitness*: expanding personal health and wellness to where people live.

Continua develops its interoperability guidelines using the industry standards. It starts by evaluating member-submitted use cases about interoperability problems and including them into a generalized list of use cases. This list is used to prioritize capabilities, interfaces, and devices and then derives the desired functionality and requirements for the next version of guidelines.

An interesting example of HKE includes *Sermo.com* (Figure 4). Sermo represents an authenticated community of physicians who contribute and filter professional knowledge. Community members of Sermo can post questions to other physicians within the network, and provide answers to questions posed by other members. Sermo is open to physicians across the US, but those who wish to join the network must provide information that enables Sermo to authenticate the fact that they are registered physicians. Registration for the Sermo website is voluntary and open to any licensed physician in the US. By default, Sermo encourages community members to participate anonymously as a mean of protecting the confidentiality of the symptoms or details of patients they may discuss online (Bray 2008).

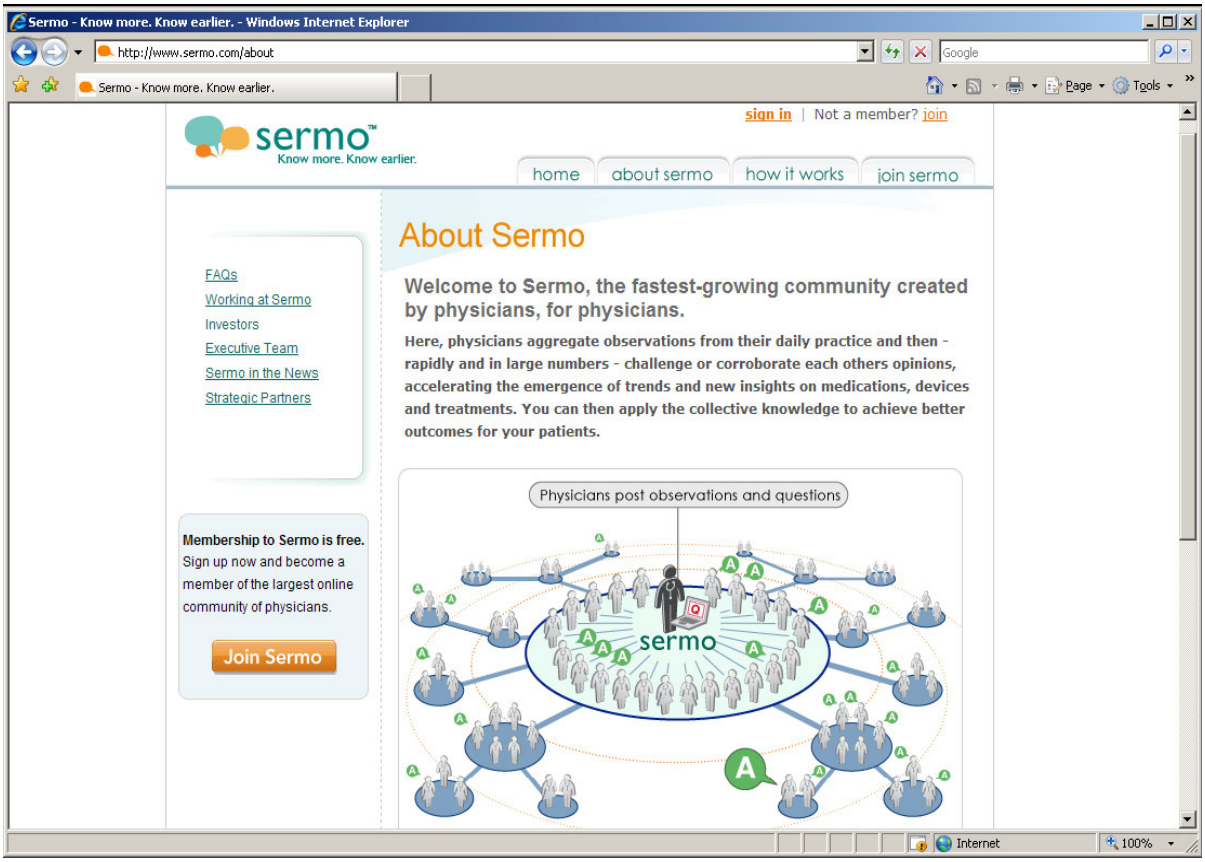

Figure 4: Example of a Healthcare Knowledge Ecosystem, Sermo.com (www.sermo.com)

The problem emphasis of the Sermo model is focused on cultivating a community-centric network that can collectively answer emergent concerns and questions relevant to its members. Network members must help each other by filtering through the exchanged insights of the community to produce stronger signals regarding important knowledge, while ignoring non-relevant noise (Rivkin 2001; Siggelkow 2005).

Sermo seeks to facilitate valuable conversations (the sharing of observations and knowledge) about healthcare and medical practices, while as social aim, Sermo seeks to foster a distributed group feeling that physicians are in a community of peers. The characteristics of its model prove that Sermo operates as a knowledge ecosystem, i.e. as a dynamic network that both fosters knowledge transfer opportunities among members and allows knowledge transfer processes to occur and evolve, as environmental circumstances require (Clippinger 1999; Hansen 2005).

3.2 HKEs in home health rehabilitation

Home Health Rehabilitation (HHR) services delivers professional and supportive services at home to recover disabled or chronically ill patients in need of nursing, therapeutic treatment and/or assistance with the essential activities of daily living. These services are appropriate for individuals who are homebound and need rehabilitation or skilled nursing services. Working in conjunction with the patient, family, and the attending physicians, a personalized plan of care need to be developed in order to help patients reach their maximum level of functioning as quickly as possible.

A solution to this particular area in healthcare is given by a Virtual Network for Home Rehabilitation (VNHR) (Scarlat 2008). Designing such a VN is equivalent with creating a real HKE where a wide diversity of real and virtual species interrelates:

- *people*: patients and their families, healthcare professionals, occupational therapists, ICT specialists;
- *organizations*: hospitals, medical products suppliers, IT companies;
- *technology*: medical equipment, computers, broadband, software components, applications, online services.

Virtual based home rehabilitation displaces areas from both supply and clinical chain to the patient own home: a VNHR is *patient-centric* instead of hospital-centric. From this perspective, we face an increasing role

of technology dedicated to information elicitation, storage, processing and transmission. But the most important feature within a VNHR consists in the *unprecedented diversity and intensity of the knowledge flows among its members* (Figure 5).

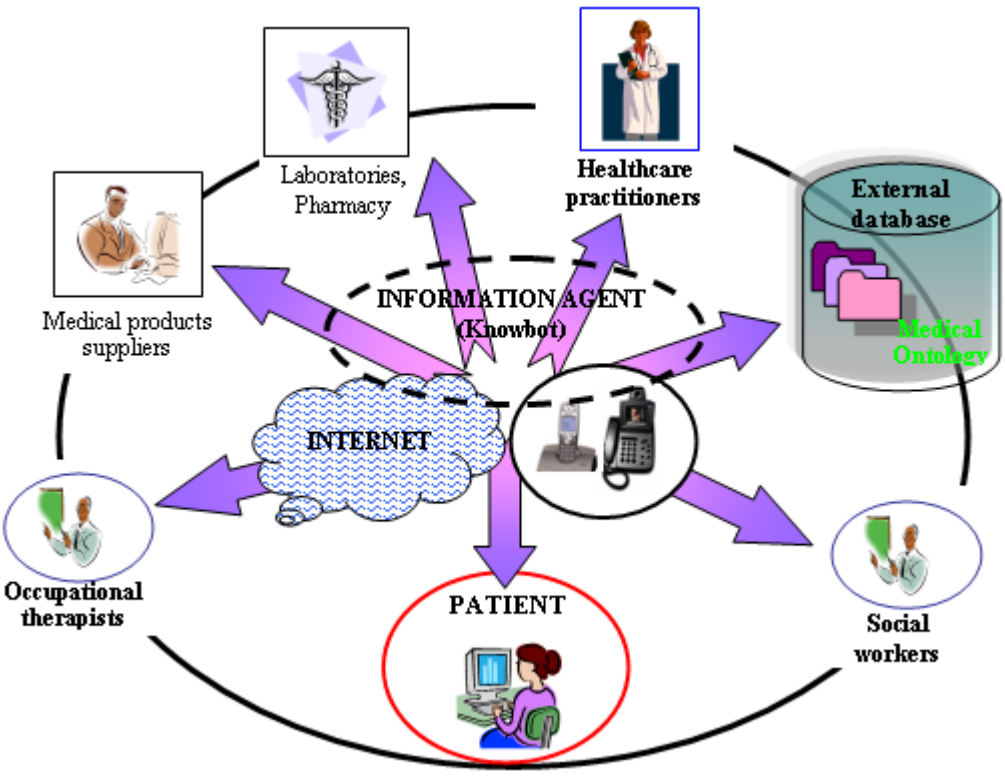

Figure 5: A knowledge ecosystem for home health rehabilitation within a VN

Healthcare practitioners having various medical competences exchange knowledge (also through systems such as Sermo) with each other, with patients, occupational therapists, social workers, medical equipment manufacturers, pharmacists, lab professionals. In this process, every member of the ecosystem learns continuously from the others and in the same time offers his own knowledge and expertise to the others. A multitude of dynamic knowledge creation processes occur when KE's members transform their *tacit knowledge* into *explicit knowledge* and vice-versa. During this permanent communication process, people within the ecosystem find out how to:

- understand each other using same language, ontology, tools, practices, medical and industrial standards;
- use the medical and IC technologies, discover its limitations and work together to improve them.

We have to remark that, in order to be a useful and effective environment, such a HKE for home rehabilitation must be driven permanently by its ultimate goal - the improvement of health and life quality of the disabled people.

Let's take a deeper look inside this particular HKE for home rehabilitation, in order to identify the main characteristics of the key actors within - "medical staff" and "patients" - and the specific knowledge flows among them. The so-called *"medical staff"* (Healthcare Practitioners) category includes: doctors, professional nurses, physiotherapists, occupational therapists, social workers. On the other hand the actor named *"patient"* is in fact a group which includes: the disabled patient, his/her family, friends, and colleagues.

These two categories of actors are characterized by three different types of interactions that generate specific knowledge flows (see Table 1):

- Type I – Interactions inside the group (red frames);
- Type II – Interactions with the other key actor's group (green frames);
- Type III - Interactions with other agents from the HKE' environment (blue frames): medical products suppliers, laboratories, pharmacy, IT specialists, and other people interacting with the disabled patient (except the ones listed in the "patients" group).

Table 1: Knowledge Flows among the HKE's key actors and agents

	"Medical Staff"	"Patients"	Other Agents
"Medical Staff"	Knowledge shared refers to: - The current symptoms and clinical parameters of the patient; - Observations and diagnosis by the physicians; - The previous known diseases or health problems of the patient; - Procedures and protocols set up in order to solve the rehabilitation problems of the patient included in his own rehabilitation chain; - MD's own experiences in similar cases.	Knowledge shared refers to: - The history of the patient's diseases; - The current symptoms of the patient; - The dynamics of the clinical parameters during the rehabilitation process. All these pieces of knowledge are stored in the patient' electronic record. The patient interacts with the medical staff both on a regular (virtual and real) consultation schedule, as well as in the emergency situations.	Knowledge shared refers to: - The new observed requirements for the medical equipments; - Adverse reactions on different medications which were not registered before; - Relevant tests needed to be added to a specific rehabilitation chain; - Necessary adjustments to the communication technology currently used within the HKE.
"Patients"		Knowledge shared refers to: - Observed symptomatology related to different stages of the rehabilitation process; - Personal experiences shared with other patients having similar impairments and being connected with the VNHR (using a dedicated blog for example); - Progresses made on different stages of the rehabilitation chain (what augmented and what slowed down the process).	Knowledge shared refers to: - Possible obstructions in using a particular medical equipment; - Side effects of certain drugs, sensors, virtual reality programs and so on; - Particular difficulties in accessing or understanding different information stored in the VN repositories; - Possible interruption in the communications with the medical staff or other agents within the HKE.
Other Agents			Knowledge shared refers to: - The new technologies that can be use in order to improve the medical equipment, and to offer new solutions for the newly occurred problems; - New achievements in the researches for new and/or better remedies for the particular problems of the disabled people; - Progresses of the IT&C technologies, protocols and procedures.

Two interesting aspects we have to notice here:

1. The knowledge flows in the red frames form real smaller ecosystems inside the HKE. Thereby, we can talk about a Medical CoP, a Patient CoP, and about the "Other Specialists" CoP;
2. The dynamic flows of knowledge among the actors are both ways oriented; this allows each actor or agent within the HKE to learn from the other actors/agents, and to evolve together faster for the benefit of the patient, as well as of the entire community of the HKE. As a result, doctors will better understand the symptoms, the reactions, and the messages coming from the patients, while the patients will understand and apply the medical procedures included in their rehabilitation chain more efficiently. Both actors' efforts will be augmented by the qualified support of all the other involved agents.

4. Conclusions

Besides the benefits of the DE, knowledge ecosystems help communities to evolve faster together by mutual sharing of knowledge and competences, leading them to a deeper understanding and a quick and better solution to the problems they are faced with. As we have seen in the third section, all the general principles introduced in the section 2 apply for a HKE as well:

1. Open communication and knowledge sharing are indeed cultural norms of the HKE;
2. Due to the knowledge dynamism the entire ecosystem evolves in time;
3. All the processes within a VNHR are based on dialog and facilitated by a complex network of relationships among members;
4. In order to prevent doctors' and patients' reticence in using it, the knowledge repositories must be permanently updated, and easy accessible when needed;
5. To stimulate the dialog between the ecosystem members, the entire technology that supports the network has to be user-friendly and fit the healthcare process requirements.

The only difference we have remarked between the HKE for home rehabilitation and other KEs consists in the particular *role and importance of the patient* among the ecosystem members. Practically, the entire "life" of the ecosystem gravitates around the patient and his personal rehabilitation chain.

Perhaps more than in other domains, in healthcare the dynamic process of knowledge creation, sharing and use is crucial. It stimulates human creativity regarding medical acts, procedures and practices, and also creates strong relationships between all the involved "actors", with a major benefit in saving lives through on-time qualified medical services. Also it is important to mention that HKEs for HHR are time and cost savings relative to the classic in-patient system (Scarlat 2008).

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