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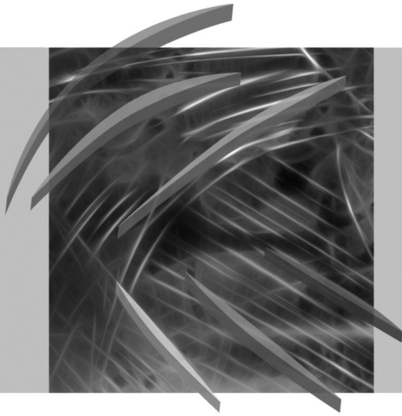

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KEY FACTORS OF KNOWLEDGE GRID DEVELOPMENT

Summary: Knowledge Grid, as a promising concept of man-computer global infrastructure aimed at knowledge services, is gradually being developed. It seems to be important, in the case of the progress of new approaches to the usage computer network resources, to identify crucial aspects of its functioning. The main goal of the paper is to investigate the main determinants of the progress in Knowledge Grid applications. There are special factors that have an essential impact on Knowledge Grid spreading apart from typical ones itemised in other approaches. Broadly speaking, the following factors can be formulated as determinants of Knowledge Grid development: technical infrastructure, economical context, environmental and social space. All the mentioned factors are discussed in particular sections of the paper.

Keywords: Knowledge Grid, knowledge development, key factors.

1. Introduction

Assumed progress in modern information society depends on better and better utilisation of information resources. Web and especially semantic web create very promising infrastructure to manage knowledge for different users and representing very far domains. The concept of Knowledge Grid (KG) consists in global management of knowledge resources, using network computer infrastructure. The basic aim of the paper is to present the essential factors that, in different ways, determine progress in Knowledge Grid.

Knowledge Grid idea is discussed in the first section of the paper. Two popular definitions, introduced the first by Mario Cannataro and Domenico Talia, and the second by Hai Zhuge, are commented on. Key characteristics of these two visions are reminded and a proposal of a unified interpretation is delivered.

Basic scenarios of knowledge grid development are considered in the next section. There are principles and strategies, defined by Hai Zhuge, worth discussing in the context of knowledge management tendencies.

The crucial and the most important part of the paper is devoted to the investigation of the Knowledge Grid determinants in the context of its development. They cover the following aspects: technical, economical, social, and environmental. Particular factors as discussed with the initial characteristics of its impact on broadly understood Knowledge Grid development processes. At the final stage, research findings are presented. Apart from concluding remarks some future works are considered.

2. Interpretations of Knowledge Grid

No doubts, there is a real necessity of gathering and distributing knowledge (as a product and heritage of past and modern societies). The challenge of offering knowledge resources via computer networks became the main inspiration of Knowledge Grid propagators. On the other hand, the Internet (often called milestones of information technology) as the global platforms of modern communication is the natural infrastructure of storing and offering many facilities for knowledge users.

At the beginning of the Knowledge Grid concepts presentation, let us recall two interpretations of this term. There are common goals and features in presented approaches despite of different starting points. Except for definitions, essential features of these knowledge grid understandings are pointed out.

According to the first interpretation proposed by Cannataro and Talia (see: [Cannataro, Talia 2003]), "**Knowledge Grid** is a software system based on a set of services for knowledge discovery over a grid". Therefore, the main assumed goal is "to enable collaboration of scientists and professionals who must data mine from information stored in different research centers or for executive managers who use a knowledge management system operating over several data warehouses potentially located in different establishments" [Cannataro, Talia 2003].

Crucial components of such defined KG are *computer infrastructure* (defined as a grid architecture), *distributed knowledge* available via specialised *grid services* (including also knowledge management processes), and loosely defined *group of users*. Therefore, the main features of such defined Knowledge Grid refer to the aforementioned components.

The first ***architectural*** property consists in developing two hierarchical layers: Core K-Grid layer and High K-Grid layer. The first core layer is responsible for discovering knowledge, whereas the second one comprises processes essential for storing and analyzing discovered knowledge. Both layers are designed for broadly speaking knowledge management processes and strictly tied to the grid concept.

The second ***knowledge-based*** **feature** determines knowledge structures as a critical resource considered in this approach. Therefore, knowledge is the main goal of all the processes existing in the grid architecture starting from acquisition up to delivering necessary output for users. Knowledge in such a system can be maintained with different levels of granularity.

The next ***service-oriented*** **characteristic** refers to the ways of managing knowledge resources. All the necessary processes included in knowledge management cycle are represented as data grid and generic grid services. Such assumptions allow for continuous and covering many variants of user's tasks performing.

The last property of the approach described is connected to ***multi-purposed methods*** of knowledge processing. This feature is directly tied to very flexible defined users which can perform different tasks requested from the Knowledge Grid platform. This functionality can be relatively easy to reach via almost unlimited and distributed knowledge available through grid architecture working basically as the unified platform using parallel data processing machines.

The second interpretation suggested a bit later by Hai Zhuge [2004], who declared that "conceptualized the Knowledge Grid is an intelligent and sustainable Internet application environment that enables people or virtual roles (mechanisms that facilitate interoperation among users, applications, and resources) to effectively capture, publish, share and manage explicit knowledge resources". In addition, Zhuge emphasised sorts of knowledge and on-demand services embracing, for example, support innovation, cooperative teamwork, problem-solving, and decision-making. Moreover, basic human cognition branches of philosophy are incorporated (epistemology and ontology) apart from principles, techniques, and standards necessary in future generation of web [Zhuge 2004].

The list of components creating KG in Zhuge's proposal involves: *Internet application environment* (as the software background), *knowledge resources* with precisely defined *management processes*, and *specialised services* limited to *widely understood intelligent performed tasks*, apart from the general assumptions of *necessary frameworks* with the cognitive context. As a result, distinguished properties of this interpretation of Knowledge Grid approach can be formulated.

The primary feature of KG – ***architectural*** – plays a similar role (comparing to the Cannataro and Talia's proposal), but there are differences at the implementation level. Zhuge proposed a mixture of technologies that support the KG vision including: the Internet, grid, semantic web services, artificial intelligence, and several others. That means rather not limited application environment focused on knowledge processing.

The next group of properties denotes specific characteristics which refer to demanding expectations on the road from "TeraGrid to Knowledge Grid" announced by Fran Berman [2001]. According to Zhuge's vision (reported in Zhuge [2004]), these characteristics embrace the following list of aspects: virtual, social, adaptive, and semantic.

Virtual characteristics of KG correspond to the aforementioned ones and recall universal platform *Virtual Grid* (VG), grouping requirements, roles, and resources. These three crucial components acquire the uniform resource model (versatile and dynamic), which is able to assist people in intelligent way in performing complex tasks and resolving difficult problems via specific *single semantic image* acceptable in the VG platform.

Considering KG ***social characteristics***, we extend virtuality by stressing participation of people in the knowledge management processes. All the resources, services, and other e-business environment components belong to society. Therefore, social (cultural and economic) rules and laws should be respected in the Knowledge Grid assumptions. Respectively, we may term this property as the *Social Grid* oriented platform, where society plays the basic roles of creators as well as users.

Adaptive characteristics of KG come from unlimited expectations of users. It is impossible to provide all potential (not only current but also future) "on-demand services" using static knowledge. Basic economic determinants of necessary knowledge are people, market and economic regulations (strategy and law circumstances), and as a consequence of changes in these factors we need "adaptive" mechanisms in working Knowledge Grid.

The last mentioned property, ***semantic characteristics*** of KG, is strictly connected to knowledge acquisition and knowledge representation procedures of knowledge management. Basically, the contents of Knowledge Grid depend on these procedures and (it is worth stressing) have an essential impact on knowledge usability. There is a real gap between different low and high level semantics in the web and a *semantic computing model* is suggested as the solution for supporting cognitive and communication processes in KG platform.

To summarise, KG interpretation of Zhuge can be presented in the graphical form (see Figure 1). Three essential dimensions are representative in this approach: knowledge (as the basic resource), semantic ability (representing "meaning" and possible interpretation of knowledge), and computing power as means of knowledge processing.

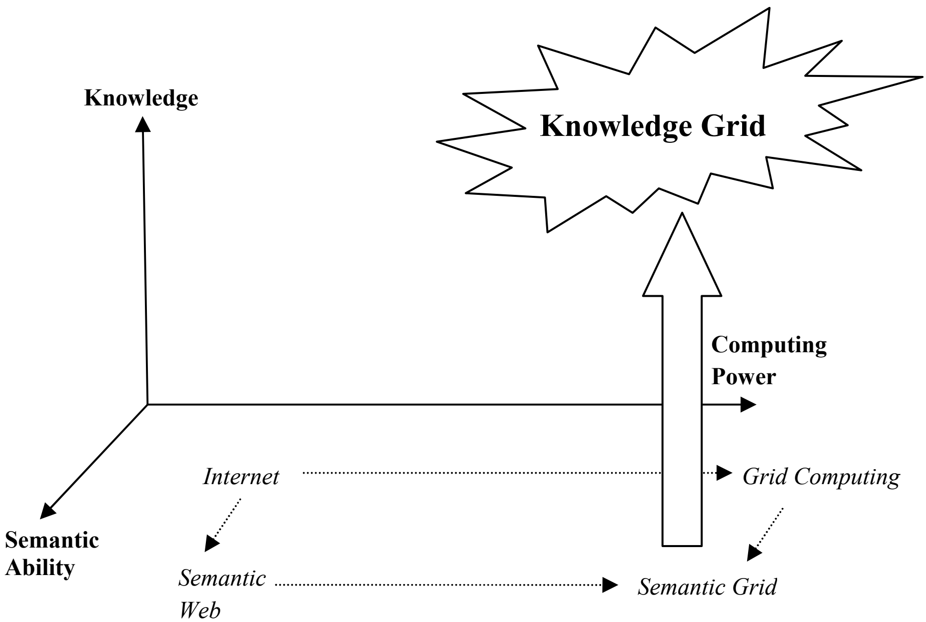

Figure 1. A reference model of generic grid

Source: author's own study based on Zhuge [2004].

The presented interpretations can be generalised underlining common features and highlighting differences between Cannataro and Talia's vision and Zhuge's proposal. Concluding, one can summarise specific features of Knowledge Grid technology in both approaches stressing its **architectural** (computer-network grid dimension*),* **knowledge-based** (contextual and owner dimensions), **service-oriented** (grid dimension), and **specific processing methods** (flexible defined processing ways dimension). All these mentioned characteristics of KG have impact on its development process.

3. Notes on Knowledge Grid methodology

It is very difficult to define successful methodology of KG development. The problem starts from different environment of the discussed concept. The KG environment consists of individuals, communities, and networking mechanisms (compare Zhuge [2008]). In addition, all these mentioned KG environment components can be considered at micro- and macrolevels. Therefore, the process of KG development can be managed in many ways using basically theories of creating complex systems. What should be stressed is the following potential theories adequate for this purpose: dissipative structure, synergetic, and hypercycle (see Zhuge [2004]).

The Knowledge Grid methodology should adopt the ***principles*** and ***strategies*** existing in social sciences, economics, and many others as well as essential for systems science [Zhuge 2004]. An overview of these mechanisms seems to be necessary to formulate KG methodology, which in fact is usually a mixture of selected principles and strategies.

First, let us recall the crucial principles useful in KG development. Some of them (*integrity and uniformity*) are crucial for typical data structures (for relational databases for example) and should be included also to Knowledge Grid infrastructure. The *hierarchical principle* seems to be very natural in KG construction; knowledge – representing different semantic spaces – should be mapped including many connections and relationships present in specific domains as well as in more global sense. Apart from rather typical principles from system's point of view (openness, necessity of optimisation, competition and co-operation, or sustainable development), it is worth stressing *self-organisation* principle. In the case of KG, we may expect these abilities achieved in the very smart way. Itemised KG environment components require active collaboration of the system parts.

In order to develop Knowledge Grid, we may use one or more strategies among the itemised below. Generally speaking, most of these strategies can be regarded as a fusion of contradict approaches. The first one (the fusion of *inheritance* and *innovation*) denotes usability of the past knowledge infrastructures but also orientation on future demanding and environment. Several fusions (*centralisation* and *decentralisation*, *abstraction* and *specialisation*, *symbolic* and *connectionist approaches*) represent verified and useful strategies in modelling typical data structures, but they are also essential for Knowledge Grid development. Applying the *incremental strategy*, we can gradually implement KG from the simplest to complex solutions evolving and engaging all the mentioned components of the whole knowledge infrastructure. A similar role can be played by the strategy termed as *crosss-disciplinary research*, in which different and expressed in many ways knowledge domains are incorporated.

In practice, we may follow methodologies of KG development rooted in more typical approaches (see Zhuge [2004]). The methodologies refer to the next proposals: object-oriented approach, based on syntax and semantics of the SQL, using semantic Web and applying abstraction to investigate a generic Grid model. Despite different categories used (entities, SQL commands, Web infrastructure or abstractions), the main goal stays the same: mapping knowledge pieces in such a way that we get Knowledge Grid as a global and networked infrastructure.

4. Determinants of Knowledge Grid development overview

Keeping in mind KG and ways of its development presented earlier, we may discuss factors which have impact on progress in the described process. In fact, there is no research in this area except for some oriented on specific solutions in Grids (compare Hwang Altmann, Mohammed [2009]). Broadly speaking, we may take into account determinants typical for any IT products as well as specific for the presented knowledge context. All these determinants can be grouped into the following categories: technological, economical, social, and environmental.

Technological aspect of Knowledge Grid development in some way is conditioning the whole concept. This is a matter of the proper computer infrastructure (mostly based on the Internet and modern information technologies), which is able to serve KG concept. Nowadays, hardware parameters as well as available software packages (especially using artificial intelligence methods) are basically good enough to support KG solutions.

Economic context of KG implementation can be basically identified with knowledge economy and in particular with knowledge network (see Chattopadhyay, Krishnan, Singh [2009]; Cheung, Liu [2005]). In other words, KG is approved when actual or future (including long-term) expectations of users are fulfill at the reasonable costs. There are many projects devoted to usability and economics of Knowledge Grid (see Akogrimo, SGL, or CoAKTinG), which lead to elaborating efficient KG applications.

Social determinants of KG development play a very essential role in the discussed problem. By its nature particular communities or the whole society are creators as well as users of the gathered knowledge. Therefore, members of society (individuals or groups) can be stimulators or moderators of the KG development. For sure the consciousness of the KG implementation necessity is growing up, which means continuous extensions of the discussed solutions in new areas.

The last introduced factor of the KG development defined as ***environmental*** expresses human-machine relationships (see Zhuge [2008]). This environment includes knowledge "actors" (individuals and self-organised communities) which act with computer networks creating specialised mechanism in order to assure ability to reach the defined in KG aims. Going into details, specialised architectures with evolving networking mechanisms for the KG environment are built (as it was mentioned in the previous parts of the paper), covering automatic clustering of users and large-scale annotated resources, scalable structures for resource organisation, and many others.

The first two factors are rather typical for any IT implementations while the last ones are specific for the Knowledge Grid concept. It is very difficult to define metrics and even to evaluate ranking of these factors, but undoubtedly the presented list covers more significant determinants of KG development.

5. Conclusions

In the paper, we first discussed the interpretation of the Knowledge Grid concept, stressing essential features of the approach and then presented KG development methodology. As a consequence, it allowed defining the main groups of determinants KG development. The basic research findings can be formulated as follows:

– generalised concepts of Knowledge Grid as the recapitulation of two common known visions of M. Cannataro and D. Talia, and H. Zhuge were discussed; the following properties seem to be essential: architectural (*using grids)*, knowledge-based (*main resource of contents*), service-oriented (*a goal of activities*), and specific processing methods (*flexible defined processing*);
– there are important and specific strategies and principles which should be adopted in the KG methodology; some of them are typical for large systems construction while some are specific for the KG approach;
– there are four groups of KG determinants: technological, economic, social, and environmental. They were shortly discussed stressing its general or specific roles in the described problem.

The future research can refer to defining the importance and metrics of the proposed KG development determinants.

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Internet resources

[Akogrimo] *Access to Knowledge through the Grid in a mobile World*, www.akogrimo.org
[CoAKTinG] *Collaborative Advanced Knowledge Technologies*, www.aktors.org/coakting
[SGL] *Semantic Grid Links*, www.semanticgrid.org/links.html

KLUCZOWE CZYNNIKI ROZWOJU *KNOWLEDGE GRID*

Streszczenie: *Knowledge Grid*, jako obiecująca koncepcja globalnej infrastruktury zmierzającej do usług wiedzy, jest stopniowo rozwijany. Ważnym wydaje się być, w przypadku rozwoju nowych podejść do wykorzystania zasobów sieci komputerowych, aby zidentyfikować kluczowe aspekty jego funkcjonowania. Głównym celem pracy jest zbadanie głównych wyznaczników postępu w aplikacji *Knowledge Grid*. Istnieją specjalne czynniki, które mają istotny wpływ na *Knowledge Grid*, odsuwające typowe czynniki wyszczególnione w innych podejściach. Ogólnie mówiąc, następujące czynniki mogą być formułowane jako determinanty rozwoju *Knowledge Grid*: infrastruktura techniczna, ekonomiczna kontekst przestrzeń środowiskowa i społecznosć. Wszystkie wymienione czynniki zostały omówione w poszczególnych sekcjach artykułu.

Słowa kluczowe: *Knowledge Grid*, rozwój wiedzy, kluczowe czynniki.