Peer to peer based network management using aggregation service

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***Abstract*—This work pretends to give an overview on the network management area using the peer to peer technology with the intent to justify a propose of building a framework of measurement/monitoring and service management using peer to peer mechanisms. Also, this work presents a proposal to address the network configuration management problem using the P2P overlay paradigm. The proposal specify a Service Aggregation in a hierarchical P2P management overlay that will aggregate management services advertisements as well summarizing relevant management informations, which will be used as input to execute some self-configuration that will address the configuration problem in P2P network management.**

I. Introduction

The development of services which run on computer networks is growing. Newer and better applications are delivered every day. Much of this services and applications have exigent necessity for support and management. So, much research has being done in the field of autonomics to address this issues. However, the main objective of the organizations which run network infrastructures are keep everything working. To accomplish that network management is necessary. There are well defined standards in this field. Simple Network Management[4], [5] is the *facto* standard protocol to manage network elements. It is based in a well defined management information model which relies on management information bases - MIBs that are kept by every network managed element in the infrastructure. The management of it can occur through a centralized model based on the client/server architecture. In this case the client will be the manager module which will receive the management informations and based on that take decisions. And the server will be the agents who will run in the network elements monitoring it and taking care of the MIB, updating it with the real time informations monitored or changing that values through a request from the manager. For that this model is commonly called agent/manager model.

The information, which will be received by the manager from the agent, can be sent in some ways. The most common is through *traps*, also known as *notifications*, which are messages sent from the agents when some programmed threshold on a specific managed object on the MIB is achieved. It means the manager must take some decision once has received that information. For instance, to close some router logical ports, less the bandwidth for some channels and so on. On the other way the manager can *pull* the agent to receive the values about a specific managed object.

This is the traditional network management scheme for managing network elements. With the growing up of the use of services deployed over the network infrastructure and its distributed execution, new ways of managing it are necessary.

Some new paradigms for network management are already envisioned and deployed. It is the case of Management by Delegation (MbD) [7]. Some related work in the section II have this work as its base. With the advent of the P2P networks with the *collaboration* and *sharing* paradigm, new approaches to network management also start up. At a first sight, the P2P applications are seen as problems in network management, due to their high bandwidth consuming and their increasing usage. However, nowadays some researches are trying to use other P2P characteristics to deploy new network management applications.

Then this work present in the section II some related works with the subject of merging the network management paradigm and the peer to peer networks. In the section III is presented a proposal to develop a framework for network management taking into account the use of the infrastructure already installed in the enterprises as bases to deploy network management in a self-organized hierarchical overlay. Also in this section are presented some expected results, where is expected publish works from this proposal, a validation scenario where to applicate the proposal as well as the next steps towards the conclusion of this work. In the section IV are presented a little insight to enhance the proposal as well the P2P network management area. Finally are presented some conclusions in the section V and also the bibliographic references used.

II. Related Works

The Celtic Madeira Project [1] intent to provide an innovative architectural framework, requisite interface protocols and/or standards and a reference software platform with prototypical implementations for a distributed network management system based on a non-hierarchical peer-to-peer paradigm. While there is much research interest in this topic, no dominant or standardised solution yet exists. The Madeira project is part of the EUREKA project. Madeira project started in 2004 and had 2 years.

Again in the Celtic Madeira Project, in the field of fault management the work from Leithner et. al. [11] utilizes the framework based on peer to peer as an overlay hierarchically formed with super nodes used the concentrate information from the peers. In the case of fault management the consolidate view of the fault is achieved in the peers before forwarding it to the top level peers.

The EMANICS Project [2] is a project focused on Network and Services Management. It conjugates a set of european partners to address scalability, dynamics, security and automation challenges that emerge towards the management plane of the future Internet and complex services running on top of it. The Figure 1 present the partners and the research topics interests in Network Management.

One of the firsts papers, according [12] relating the use of peer to peer networking to network management was the work from Sate and Foster [15]. The work from [15] proposes the use of a peer to peer framework as an integration model for distributed management architecture initially designed for monitoring and configuration of mobile devices. The management of peer to peer services relies on: 1) Dynamic discovery of "to be managed capable" services and devices. The authors propose the use of an advertisement service in order to expose the management interface of a service or a device. That is, a service willing to be managed will announce this will. The advertisement consists in providing the description of its management interface as well as the access to the latter. The access to the management interface is provided over the proposed JXTA pipe mechanism. 2) Dynamic discovery of communication channels towards the management services. The authors propose the use of a management pipe for invoking management operations. The advertisement of a management interface is associated to the advertisement of a pipe used to deliver the management actions. The usage of one to many pipes is particularly suited to rapidly manage a large set of entities. 3) Extending the service advertisement in order to include service dependencies.

The work from [8] presents a model of network management based on P2P networks. Using the P2P infrastructure the authors propose a mix of network management by delegation and P2P networks. The following elements are used: TLM (top level managers), MLM (middle level managers) and SNMP agents on the devices. The TLM and MLM are manager software running as peers in the P2P network performing the management tasks. The human manager interact with the TLM which interacts with the MLM. Three management cases are demonstrated using ManP2P as a tool developed for. This tool can act as TLM or MLM depending on the task to be executed and the behaviour wished by the operator. The following three "requisites" are presented to justify the use of that framework. **Human based cooperative management**; where the human manager execute information exchange using TLMs. **Improved connectivity for message exchange**; where a human manager acting in a specific domain can manage devices in another through the routing capabilities provided by the overlay formed by the MLMs as peers. **Management tasks load balancing**; where the MLMs arrange themselves in groups of managers which contribute to deliver high availability to the management service and also management tasks load balancing using the Weighted Round-Robin Scheduling. One specific management problem treated in this approach is the configuration management where the devices' configuration files can be searched around the P2P network downloaded, changed and after that applied to a specific device through the MLM peer closest the device to be managed. Other problem addressed is the shared network view among the network operators through the sharing of topology files. Of course is necessary to constraint the access to this informations just for the people authorized. Also, handling the distributed notification is a problem treated.

The main contribution of that work is the possibility of manage different devices in different domains through the P2P application level routing of the requests. This capability overpass the difficulties found when using pure SNMP through firewalls and NAT systems.

Following the work from [8] which presents the base ManP2P architecture for P2P-based network management the work from [12] uses that infrastructure to evaluate the performance of notifications using a hybrid P2P-based network management. To do that the interested TLMs must subscribe for the notifications. Thus in the MLMs there are modules which receive and store the requests for notification at the same time that there are modules for forward the notifications for the correct TLMs when they arrive. Some XML files are used to store the TLM and the types of notifications. Devices SNMP aware trigger traps to Middle Level Managers (MLM) and in this case forms the P2P overlay first level for the ManP2P tool. That traps, also called *notifications*, are forwarded to the Top Level Managers (TLM) which are the peers that form the front end of the management system to the human operators. The *speedup*, understood as the difference between sending the notifications in a sequential or in parallel fashion is measured. Also was measured the average notification processing delay to send it to the TLM. In all these experiments were used a fixed scenario varying from 1 to 12 TLMs and from 1 to 3 MLMs.

The merging of network management, peer to peer networks an autonomic computing [9] can be seen in [13]. That work presents an architecture for managing services in a P2P environment. The tool is called Autonomic ManP2P and is obviously derived from the work of [8]. The work is done by

autonomic management services which manage, monitor and configure services. The architecture is based on a self-basic service and self-specific services. The self-basic service has the function of managing the self-specific services which manages the specific services (i.e. DNS monitoring, BGP monitoring and so on). The services execute in the P2P overlay. To control the managed services in an autonomic fashion the self-basic service as well the self-specific services relies on policies. To the former the policy is executed to configure the self-specific services, that means basically instantiating those services. To the latter the policy is stated to heal (basically finding another peer in the overlay which can instantiate the service and keep it running). Each peer is called an autonomic peer, and in that work the peer is split in the autonomic execution that comprehends the Self-Basic service plus the Self-Specific service that are the self-monitoring and self-configuration services and the non autonomic execution part that comprehends the SNMP trap monitoring and the web services notification monitoring.

The work from Panisson e.t. al. [14] describes the conception, design and implementation of a P2P based network management system. It defines the concept of Management Service which is executed by the Management Component that is encapsulated and controlled in a compositive Container that is hold by a MLM (a peer). That work shows the interaction between the TLM, which plays the role of a front end to the user and the function of high level manager, and the MLM to search a Management Service. The Management Service is initiate and advertised by the Management Component carried by the Container. The work presents the API designed for the Management Component and also for the Management Service.

We can realize that some works are connected with a strong architecture for P2P-based network management illustrated by the ManP2P tool. This tool is built on the top of the JXTA technology [3] and it provides the mechanisms necessary to evaluate notifications [12], offer human based management cooperation, configuration management, network shared view and so on [8].

The work from Binzenhöfer e.t. al. [6] proposes a distributed, self-organizing, generic testing and QoS monitoring architecture for IP networks. The architecture is based on equal agents denoted as Distributed Network Agents (DNA), which form a management overlay for the service. The self-organization of the overlay is achieved by a Kademlia P2P network. The architecture intend to support the central network monitoring station. There are the main component from the DNA architecture that is the Mediator which runs in background and is responsible for the communication between the user and the individual test modules. There are local tests that can be scheduled by the users and also it has distributed tests that can be executed with the collaboration from the DNAs agents belonging to the overlay. The tests are mainly concerned with connectivity. There are in the architecture a series of pre-defined tests. It is possible to deploy new tests if there is trust between the entity which deploy the tests and the DNA agents.

An improvement proposal in manage peer service in JXTA services called PSMI - Peer Service Management Infrastructure is presented by Yang e.t. al. [16]. According the authors their architecture, which uses a web service registry and a mechanism called SCI - Service type based Classification of Index, improves the discovery of the peers offering a specific service on the overlay formed by the JXTA framework. That assumption is evaluated using the WSR - Web Service Registry, which is part of the PSMI, with the help of the expiration, QoS, security, and TTL parameters given by the service provider.

III. Proposal

Observing the related works we can realize some works merging network management and P2P networks. They use the self-organizing property of these overlay networks to scale inter and intra domains management. Most of those works rely on a base implementation of an architecture which can be deployed along the nodes of the network to provide management services.

Implement a prototype for network management using P2P JXTA technology is what this work proposes. Each peer in the network will be able to execute some management functions. The interaction with SNMP agents running in devices SNMP aware will be one of this functions. Expose Management Services will be another one. The specification of what will be Management Services needs be done. Primarily it could be the monitoring of well known services such as DNS, DHCP, firewall and NAT services. But it also could be monitoring the web server memory level for instance. Also, when the end users machines can take part of the management overlay the Management Service for it could be reserve end to end bandwidth for a VoIP communication. Using this idea the high level manager can also request the groups formation to execute a management task which require some level of cooperation among the peers such as analysing some notifications to correlate them before inform to the high level manager.

Then, unlike the previous works which try to deploy a generic framework based on MLMs and TLMs this work proposes the introduction of a new component responsible to aggregate the Management Services advertisements from specialized management peer agents. The aggregation model will be the publish/subscribe, where peers offering some special management service can advertise themselves and the managers interested in it will be pushed about those services. This component also make part of the overlay and can act as a super-peer keeping the digest of the services. It is expected that this component can improve the search for specialized management services. These advertisements will be looked up by the high level managers in order to know which agents in the peers can execute those specialized management services. The specialized management agents can join the overlay in an indeterministic way offering their services. New management services could be deployed in the overlay in a natural way, just starting up the software. After that it will advertise its

management aggregation service peer (super peer) and it will be able to be used by the TLM. The Figure 2 shows some components on the network.

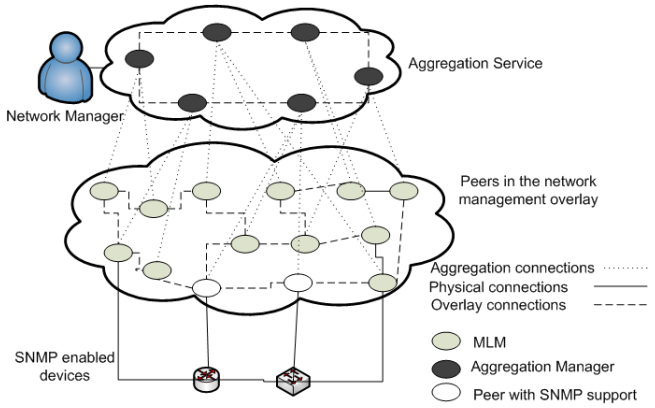

Fig. 2. P2P Network Management Overlay

To differentiate this proposal from other works this work pretend address the configuration management problem. Using the idea of collaborative management from [8], this proposal also pretends to use the Aggregation Service peers as configuration elements for the services disposed in the P2P network. These peers should execute self-configuration according the information it aggregates on the monitoring process. For instance, with the aggregated download bandwidth information these special peers can try to increase the total bandwidth reserved to those sessions, or to set a rule in the firewall temporarily blocking the access to some download site. The Aggregation Service in this proposal then depicts relevant importance in the sense it can concentrate and summarize management informations to support the Self-Configuration module.

With the effect of comparing the proposals and to differentiate it some requisites were identified in the related works, which characterize and justify the applicability of the P2P paradigm to network management. These requisites are used as comparison metrics among the proposals and it can be seen on Table I.

The Cooperative Management requisite is related with the interaction among the human managers from different administrative domain. It concern with the information exchange using the peers with functions of high level management and front end to the administrators, also called human managers in this work. As the proposal of Binzenhöfer [6] concerns with the execution of distributed tests the Human Cooperative Management makes no sense once the tests are distributed among the peers and executed without human interaction.

The Load Balancing is related with the clustering formation among the peers to execute management tasks in a performed fashion. It explores the group formation to deliver high availability and processing power. The Granville [8] work uses the Weighted Round-Robin Scheduling to execute the load balancing among the peer.

TABLE I
REQUISITES TO P2P NETWORK MANAGEMENT & PROPOSALS

	Proposals		
Requisites	Granville [8]	Binzenhöfer [6]	Fiorese
Cooperative Management	☑	☒	☑
Load Balancing	☑	☒	☑
Message exchange	☑	☒	☑
Self-Organizing	☑	☑	☑
Self-*	☒	☒	☒
Self-configuring	☒	☒	☑
Aggregation	☒	☒	☑
Support for SNMP devices	☑	☒	☑
Inter-domain management	☑	☒	☑
Support for central monitoring	☒	☑	☒

When peers are physically connected on different network domains but belong to the same management domain the management information exchange is possible and also an advantage to the network or services administrators. That is what the Message Exchange requisite means, i.e., the information exchange among different domains through the use of the routing capabilities provided by the peers overlay.

The Self-Organizing is a intrinsic characteristic of the peer to peer networks. In this sense the proposals which intent offer management services using a peer to peer overlay network are Self-Organizing. It means the peers have the capacity of to form by themselves the connections among them which allow them to form the overlay.

The Self-Configuring requisite is a little controversial. In the Granville work, is cited that the configuration is a problem treated. There, the network elements configuration files can be searched, downloaded and applied to the specific network element (router, switch, and so on) through the overlay formed by the MLMs. In our understanding this approach is not self-configuring once its necessary the interaction of a human administrator to command that activities. Then the self-configuring requisite presented here is related with the capacity of the peers execute some autonomic arrangement in the overlay or in the SNMP able devices according to the informations monitored and aggregated on the aggregation layer by the special aggregation peers. In this sense our proposal is the only one which pretend to treat this characteristic.

As already explained the Aggregation characteristic is another differential on our proposal. It concerns with the capacity of the peers aggregate relevant informations from a group of intermediary peers (then the aggregation peers can act as super nodes for this purpose). In the specific case the aggregated information can be the group's power processing and the download bandwidth available.

Support for SNMP devices is related with the possibility of execute retrieval and setting of MIB informations on the managed network element able to the SNMP protocol. Is important that a new management platform complies with the legacy investment done by the enterprises and organizations

on equipments able to SNMP.

Inter-domain management is a requisite related with the own formation of the overlay. Once the peers can be located in different network domains, they can provide informations about them in accordance with special authorization and authentication policies.

Support for central monitoring is also controversial once in all proposals a network administrator can in a centralized fashion distribute management tasks. However, the proposals are totally distributed in the sense of no existence of just one central manager. The management activities are cooperative. Then, just Binzenhöfer [6] uses this requisite once his work address the execution of distributed tests over a peer to peer overlay.

In terms of architecture our proposal sets up a modular configuration. In the bottom of it will be the JXTA [3] protocols which will support the communication among the peers as well handling the advertisements which will be used to aggregate the management services and informations.

On the top of the JXTA protocols the management services will take place. This management services will be built in a modular way allowing future users of this framework integrate new management services. These management services will be responsible to monitoring the peers activities concentrating and summarizing the management informations which will be aggregate by the super peers. The management services also should advertise themselves to the Aggregation Service peers describing the management services offered that will be able to be looked for the TLMs and consequently be used by the human managers.

Over this two supportive layers will be found the two main modules of this proposal. The Aggregation Service and the Self-Configuration modules. The architecture skeleton can be seen in the Figure 3.

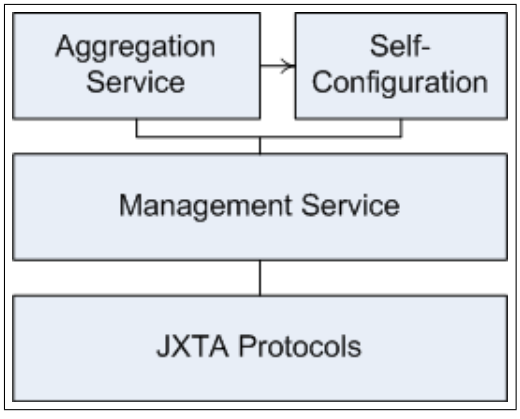

Fig. 3. Management P2P Framework Layers

The Aggregation Service module will be responsible for concentrate the announcements (advertisements) of specialized management services from the peers running them as well as concentrating the informations monitored by these services in order to summarize them to the high level managers (TLMs) and at the end, to the human managers. It is a essential part of the framework and can be implemented as a module present in every peers but which will be activated only in a few set of it which will act as super peers.

The Self-Configuration module will use the summarized informations kept by the Aggregation Service and will execute automatic configurations on the devices belonging to the network infrastructure or to the services running over it, based in policies depicted in XML files. This module must expose a public interface that will be able to be used for new autonomic configurations developed in the future for new services, devices or policies.

A. Expected Results

With this proposal is expected that the network management would be done more transparently to the network managers. Also the applicability of the peer-to-peer paradigm to network management is expected to be recognized.

Comparable results in future designed scenarios for simulations also is expected. The future scenarios are related with the capacity of aggregating different informations in different P2P overlays, as well different configuration schemes based on the aggregated informations.

B. Expected Publications

Is expected publish on the IM (IFIP/IEEE Integrated Management) conference, NOMS (IEEE Network Operations and Management Symposium) conference and others, respecting the scenarios designed for the implementation and the call for papers. A deeper research must be done looking for some journals where would be published the thorough work.

C. An applicable scenario

The search of web services nowadays are executed through queries to the UDDI's. Some service which want publish its interface and description should register itself in a repository which should be looked up for the clients who want use it. This registration and exposure is made through XML files whose content is a structured text wrote following the WSDL (Web Services Description Language) pattern, which describe the service with name, location, parameters needed and so on. Some problems, mainly the scalability of the UDDI servers can interfere in the use of it.

Disposing this WSDL specifications (XML file) in the own machine which provide the web service, or putting it on a machine which belongs to a specific web service overlay could improve the search mechanism once the high performance search already done by some peer to peer networks. For instance, some structured DHT - distributed hash table based peer to peer networks indexes the content associating the SHA-1 hash of the content name with the SHA-1 hash ID of the host which belong to the network. In this case the search is done through the routing of the query through the nodes ID which best match the hash.

Once the services providers belong to this P2P network and share its WSDL specifications the easiness in compose the

services could be increased. Thus, the clients will have a new way to search for web services. After finding it they can use it directly through the SOAP invocations.

The web services offering could be a service managed by this framework proposed, in order to aggregate the information about which peers in the overlay keep web services as well its WSDL definition. In this way a search will be able to be executed with a superior performance just configuring the web services clients to request to one of the high level managers (TLMs) for the web service wished. In this case, the TLM will ask for the Aggregation Service peers, which it have contact, for the requested web service and then it will respond with the information about which peers (IP address and other informations necessary) have it. In this case the peers which are keeping and running the web services will advertise this using the JXTA infrastructure protocols through a pipe to the Aggregation Service peer which it is subordinated in the hierarchical P2P overlay.

D. Next Steps

As a next step the JXTA must be understood and some little experimentation should be done. It will concern with the capacity of JXTA to aggregate informations on the aggregation layer of this proposal.

Start to implement a prototype to validate the proposal. This implementation will use Java as the programming language once the JXTA technology will accommodate it better.

Start to implement a simulation in the *PeerFactSim* [10] simulator to validate the proposal.

Other step is to prepare a paper to submit to some conferences to get some feedback from the research community to the idea.

IV. Future Works

For this proposal a future work can be the design and implementation of new scenarios to test the applicability of it. The results from the simulations or deployment of this scenarios would be compared to extract performance metrics such as management reaction time to a high churn in the P2P environment, for instance.

Also, as a future work in the field of P2P network management, the implementation of other self-* characteristics can be seen as a good improvement.

V. Conclusions

There are massive efforts on researching new paradigms to network and services management. Projects involving many partners are researching the applicability of the peer-to-peer paradigm to the management.

Contributions in terms of network management from the P2P paradigm are good. The possibility of executing the management inter-domain through the use of peers that behaves like belonging to just one domain is a contribution to the network and services management.

The use of peer-to-peer applications is growing up in the world. That applications are not restricted to the resource sharing, but also the the content distribution, processing power sharing and distribution targeting quality of experience to the final users. The management in terms of controlling the use of the network and services infrastructure as well as the own peer-to-peer applications is a necessity.

The proposal of relevant information aggregation by super nodes in a peer-to-peer overlay as well as the self-configuring that is possible to reach from it are characteristics already not commented on the technical bibliography about peer-to-peer network management.

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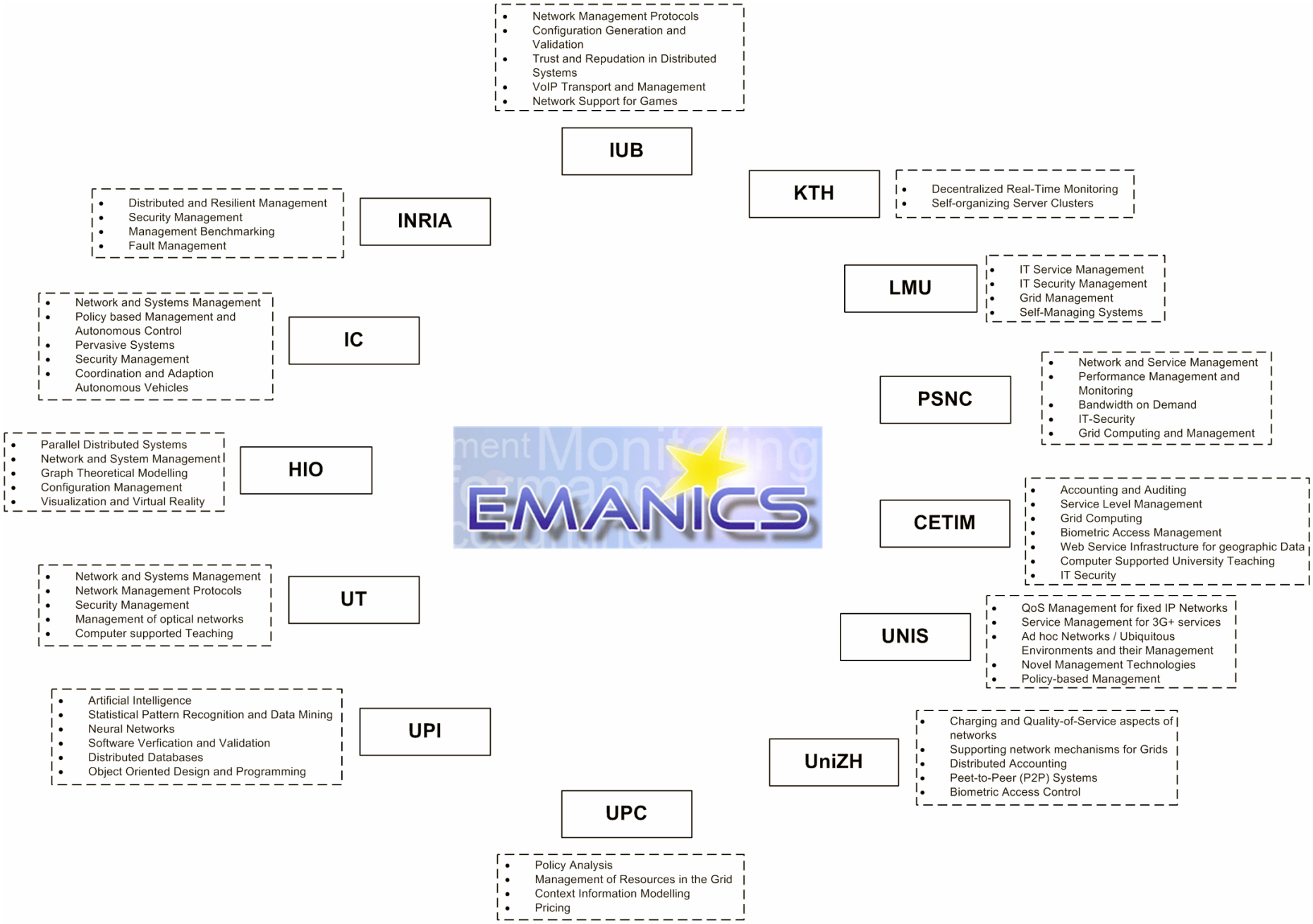

Fig. 1. Research map from all Emanics Project partners. Source D1.1 from Emanics project [2]