Assessment of multi-domain network management through P2P

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***Abstract*—This work pretends to give an overview on the network management area using the P2P technology justifying a propose of building a framework of measurement/monitoring and service management using P2P mechanisms. Our proposal specify a Service Aggregation in a hybrid/hierarchical P2P management overlay that will aggregate management services advertisements as well summarizing relevant management informations, which can be used as input to execute some self-configuration on the overlay or on the underlying network.**

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 is to keep everything working. To accomplish that the network management is necessary. There are well defined standards in this field. Simple Network Management[4], [5] is the *de 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 the infrastructure 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 information and based on that take decisions. And the server module are the agents which will run in the network elements monitoring it and taking care of the MIB, updating it with the real time information 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 it has received that information. For instance, to make some router logical ports able or unable, to 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 most used network management scheme for managing network elements. With the increasing use of services deployed over the network infrastructure and its distributed execution, new ways of managing it are necessary.

Some other paradigms for network management are already envisioned and deployed. It is the case of Management by Delegation (MbD) [10]. 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 started up. At a first sight, the P2P applications, mainly the file sharing ones, are seen as problems in network management, due to their high bandwidth consuming and their increasing usage [9]. However, nowadays some researches are trying to use other P2P characteristics to deploy new network management applications making them allies in the management task. With respect the taxonomy it must be noticed in this work we will use the term *node* and *peer* interchangeably, meaning the entity which provide or execute some service and communicates with other entities playing the same roles in an overlay network.

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 P2P 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 hybrid/hierarchical overlay. Also, in this section is presented the current development stage focusing the validation of the ideas through the simulation of this P2P framework. In the section IV are presented a little insight to enhance this work 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

Some current international relevant research projects can be cited in the network management area. 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 standardized solution yet exists.

Again in the Celtic Madeira Project, in the fault management field the work from Leithner et. al. [14] utilizes the framework based on P2P 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 toward the management plane of the future Internet and complex services running on top of it.

According [15], one of the first papers relating the use of P2P networking to network management was the work from Sate and Foster [20]. That work proposes the use of a P2P framework as an integration model for distributed management architecture initially designed for monitoring and configuration of mobile devices. The management of P2P 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 it. The access to the management interface is provided over the proposed JXTA pipe mechanism. 2) Dynamic discovery of communication channels toward the management services. The authors propose the use of a management pipe (communication channel) to 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 [11] 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, then 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 the topology files. Of course was necessary to constraint the access to this information just for the people authorized. Also, handling the distributed notification is a problem treated.

Following the work from [11], which presents the base ManP2P architecture for P2P-based network management, the work from [15] 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 and also there are modules to forward the notifications to the correct TLMs. 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, P2P networks and autonomic computing [12] can be seen in [16]. That work presents an architecture for managing services in a P2P environment. The tool is called Autonomic ManP2P and it is derived from the work of [11]. 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. [18] 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 [15], offer human based management cooperation, configuration management and network shared view .

The work from Binzenhöfer e.t. al. [8] 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 two tests' categories that can be executed. There are local tests that can be scheduled by the users and also the 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 predefined tests. It is possible to deploy new tests whether exists a trust relationship between the entity which deploy the tests and the DNA agents.

In the Ambient Networks [7], where the wireless connectivity network infrastructure and mobile devices are used to configure distributed and dynamically forming networks, a P2P management [19] scheme was proposed to deal with the highly dynamic bridging between different networks.

An improvement proposal in manage peer service in JXTA services called PSMI - Peer Service Management Infrastructure is presented by Yang e.t. al. [21]. 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.

Studies in the P2P network field sometimes are conduced using simulators. The P2P network simulators differentiate from network simulators due the capacity to provide mechanisms for high scalability approaches. There are some P2P network simulators, each one with capabilities and trade offs [17]. In this work it will be used the PeerfactSim.KOM simulator [13] once it was developed in the context of the project CONTENT [6] in which the authors are part of.

III. Framework

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 infrastructure network to provide management services.

An aspect not well mentioned in the approaches that use P2P as tool for network management is the boundaries in network administrative domains. The most used tools for network management acts in a specific administrative domain. On the point of view of the scalability this approach needs some other responses. One of them is the P2P. Once the P2P overlay can be formed using nodes belonging to different administrative domains we can say that is technically possible to reach a high scalable management platform.

This work pretends to present a P2P framework as tool for network management that differentiate from the works already done through the addition of new services, but basically exploring the cross domain ability of the P2P overlay.

For that, each peer in the network overlay 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 analyzing 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/query, where peers offering some special management service can advertise themselves and the managers interested on it can make queries about those services. This component makes part of the overlay and play the role of a super-peer keeping the digest of the services. It is expected that this component can improve the speed search for specialized management services. These advertised management services will be looked up by the high level managers in order to know which management services providers and their public interfaces in the peers can execute those specialized management services. The specialized management services providers 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 one of the TLMs. The Figure 1 shows some components on the network.

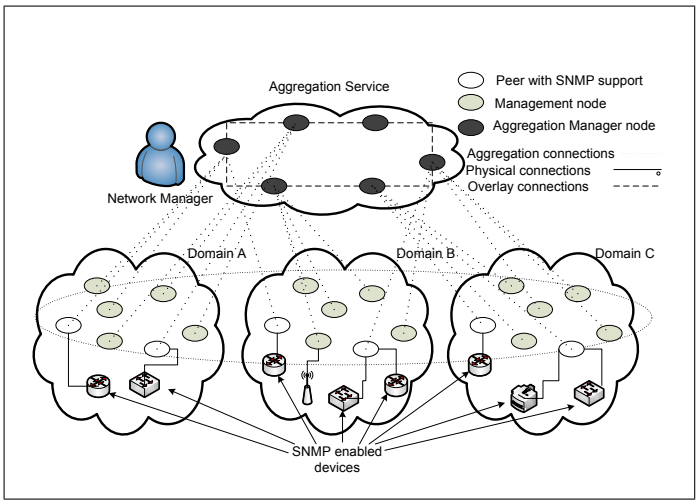

Fig. 1. P2P Network Management Overlay

To differentiate this proposal from other works we pretend to address aspects of the configuration management problem. Using the idea of collaborative management from [11], this proposal also pretends to use the Aggregation Service nodes as configuration elements for the services managed in the underlying network of the management P2P overlay. This means the peer running Management Services will not only advertise its services, but also information which can be used in the configuration process. Then, the Aggregation Service peers (super-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 on the firewall temporarily blocking the access to some download website. The Aggregation Service in this proposal then depicts relevant importance in the sense it can concentrate and summarize management information to support the Self-Configuration module.

With the effect of differentiate this work from some of already proposed, 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.

TABLE I
REQUISITES TO P2P NETWORK MANAGEMENT & PROPOSALS

	Proposals		
Requisites	Granville [11]	Binzenhöfer [8]	Fiorese
Cooperative Management	☑	☒	☑
Load Balancing	☑	☒	☑
Message exchange	☑	☒	☑
Self-Organizing	☑	☑	☑
Self-*	☒	☒	☒
Self-configuring	☒	☒	☑
Aggregation	☒	☒	☑
Support for SNMP devices	☑	☒	☑
Inter-domain management	☑	☒	☑
Support for central monitoring	☒	☑	☒

The Cooperative Management requisite is related with the interaction among the human managers from different administrative domains. 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 [8] 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 [11] work uses the Weighted Round-Robin Scheduling to execute the load balancing among the peer.

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 P2P networks. In this sense the proposals which intent offer management services using a P2P 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 aware devices or in the management services providers, according to the information monitored and aggregated on the aggregation service 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 information 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/or the download bandwidth available.

Support for SNMP devices is related with the possibility of execute retrieval and setting of MIB information 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 SNMP aware.

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 information 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 [8] uses this requisite once his work address the execution of distributed tests over a P2P overlay.

In terms of architecture our proposal sets up a modular configuration. In a first glance we think 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 information.

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 for monitoring the peers activities concentrating and summarizing the management information which will be aggregated 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 2.

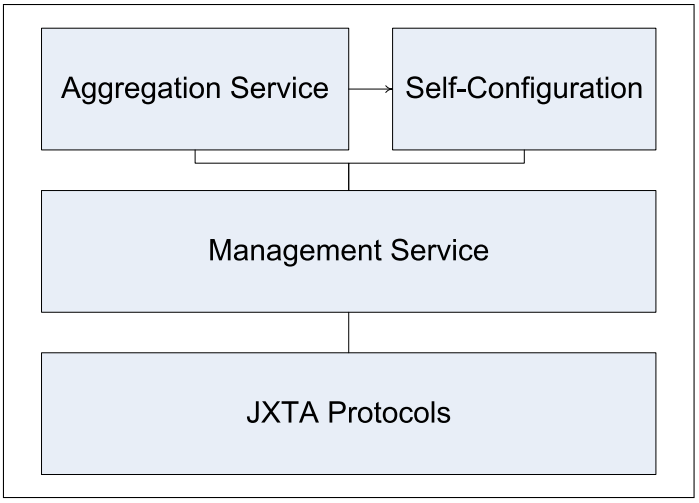

Fig. 2. Management P2P Framework Layers

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 information 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 information 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. Implementation and Expected Results

With this proposal is expected that the network management would be done transparently to the network managers. Also the applicability of the P2P paradigm to network management is expected to be recognized. We expect with this work to answer some questions. One of them is what kind of overlay routing scheme (unstructured or structured) for this management P2P framework would be better? There is some influence of the topology? What is the best way in the organization of the management services digest? How churn affect this approach?

These and other questions will be raised and to accomplish that simulations are necessary. In this work will be used the

PeerfactSim.KOM simulator as already explained.

B. Simulator

The PeerfactSim.KOM simulator is a discrete event simulator written in Java which allows the creation of an overlay and simulate large-scale P2P networks with it. Its functionality can be expressed in terms of layers implemented in separated packages in a set of interfaces, abstract classes and classes. This layers worries about the abstracted aspects from the underlaying network and the aspects of the P2P application. In this sense we can distinguish the network and transport layers, implementing the necessary mechanisms to identify underlying network nodes as well the transport mechanisms to exchange messages among them. The application layer covers the kind of overlay and the user layer covers the behaviour of the overlay's user. The simulator allows until 10^5 nodes depending on the type of the overlay simulated.

According to the documentation the main aspects an overlay developer must implement to evaluate his P2P overlay application is to identify the overlay's node, establish the overlay's node contact (its address and transport abstractions), identify the messages that can be exchanged among the nodes (peers), develop the routing table that each node should keep and maintain, develop the commands like join, leave, ...that the nodes must execute, and create the components (nodes, operations, scenarios) using the Abstract Factory Design Pattern to inform the simulator core to instantiate them to use in the simulation.

The simulation is configured using external files, consisting of a XML file which contains the classes to be loaded for the simulator and an action file in a specific text format, describing the topology of the overlay as well the operations to be executed by the simulator.

C. Functional Simulation Aspects

At this stage, simulation is being implemented. In our first attempt to identify the nodes we developed an implementation of an OverlayID that allow us to identify the nodes (peers) in a key space of 32 bits. It can sound a short range of identifiers once either nodes and keys are represented on this range in the greatest majority of the structured overlays P2P. However in our approach the key, representing the interfaces the managed services have, can be represented as plain text. An example could be the key representing the SNMP service running at a node in the domain A, from the Figure 1. It will be published and searched as SNMP@DomainA. Our overlay keeps this key in the aggregation node for which the node running the service published it. Thus, the search can be done through this key, and the identifiers will be used just to identify the nodes allowing more than two million of nodes participate in the aggregation service as an overlay.

Our simulation implementation has two kind of peers.

1) Management nodes which can interface with legacy management applications like SNMP ones, or others management services providers. These nodes will be responsible to execute the management services and to collect management information in a time interval; including to be responsible for some monitoring abilities in special underlying network services, such as DNS or DHCP. They will publish (advertise) their specialized management services in the aggregation peers. Each management node will keep a set of references saying who is its aggregation super-peer.
2) Aggregation nodes which will receive and keep aggregated the published information from the management nodes in order to facilitate the search and consequently the fast decision taken by the human managers. These aggregation nodes can keep references (as a routing table) of its neighbors, that can be used in a query search. They also should keep a set of its hierarchically subordinated management nodes to be transfered to another aggregation peer in the case of leaving operation.

The basic relation between this two kinds of nodes (peers), which constitute the core of this work, can be seen on the Figure 3. That interaction occurs through messages exchanged among the nodes. We can see the message PUBLISH sent from the management nodes to the aggregation peers carrying the management services and/or information to be published. This will happen just after the management nodes as well the aggregation nodes join the management P2P network. The "production phase" concerns the operation of the management P2P application by the human managers. They start commanding operations through the aggregation nodes. The operations are related with the search for management services, search for peers which can execute some particular management service or search for summarized management information. And of course, for using that search results, i.e., executing management operations. That phase is illustrated by the exchange of the QUERY and QUERYREPLY at the overlay level and by the connection and messages exchanging among the manager (aggregation node where the human manager will be) and the management node running the service. The management operation will be done directly among the manager and the management service provider. In that case, each particular legacy service will be commanded by its own protocol. Our simulation concern about the looking for the services interfaces, which is performed in the overlay representing the aggregation service.

As we can see the architecture aspect of the framework can be classified as hybrid in an internal view, once the management nodes are attached to a central aggregation node, but among the aggregation nodes the topology is a ring, which represents a more distributed architecture. This mix allows the high scalability once the P2P ring can be formed by a relatively few number of aggregation peers belonging to different administrative domains where each one takes care of a big number of management nodes inside these administrative domains. This approach allows a higher number of administrative domains to belong this P2P network management framework.

D. Next Steps

To make a complete simulation of this environment it will be necessary to model and implement a robust division of

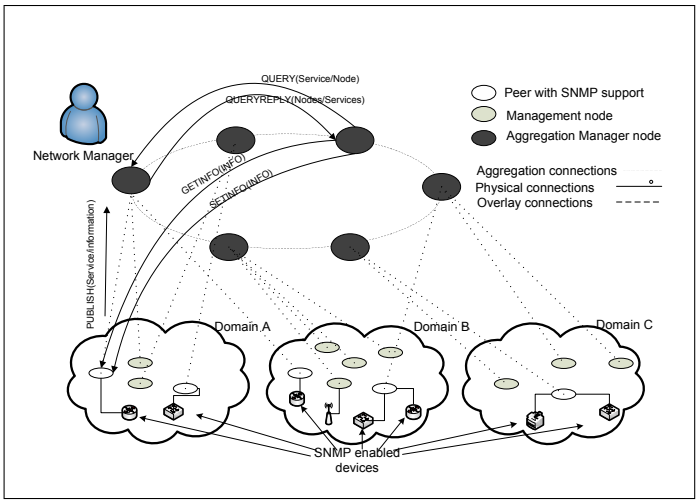

Fig. 3. Management P2P Framework Operation

administrative domains in terms of the grouping of underlying network IP addresses. As we know the real administrative domains use firewalls and NAT to protect its internal network. This aspect also should be taken into attention in some way. It is known that in real implementation of P2P file sharing systems, this aspect is commonly treated using traversal techniques.

IV. Future Works

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

An interesting future medium term work can be the benchmarking of this management P2P application running over a CHORD and/or Pastry overlays.

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 P2P paradigm to the management.

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

The use of P2P 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 P2P applications is a necessity.

The proposal of relevant information and services aggregation by super-peers in a P2P overlay as well as the self-configuring that is possible to reach from it are new opportunities that at the best of our knowledge are already not commented on the technical bibliography about P2P network management.

References

[1] "Celtic madeira project." [Online]. Available: http://www.celtic-madeira.org

[2] "Emanics project." [Online]. Available: http://www.emanics.org

[3] "Jxta project." [Online]. Available: https://jxta.dev.java.net/

[4] "Rfc 1157 - snmp: Simple network management," 1990. [Online]. Available: http://www.ietf.org/rfc/rfc1157.txt

[5] "Rfc2571 - snmp v3: Simple network management protocol v3," 1999. [Online]. Available: http://www.ietf.org/rfc/rfc2571.txt

[6] "Content project. ist fp6 0384239," 2006. [Online]. Available: http://www.ist-content.eu

[7] B. Ahlgren, L. Eggert, B. Ohlman, and A. Schieder, "Ambient networks: bridging heterogeneous network domains," *Personal, Indoor and Mobile Radio Communications, 2005. PIMRC 2005. IEEE 16th International Symposium on*, vol. 2, pp. 937–941 Vol. 2, Sept. 2005.

[8] A. Binzenhöfer, K. Tutschku, B. Graben, M. Fiedler, and P. Arlos, "A p2p-based framework for distributed network management," in *Wireless Systems and Network Architectures in Next Generation Internet*, ser. Lecture Notes in Computer Science. Springer Berlin / Heidelberg, 2006, vol. Volume 3883/2006, pp. 198–210.

[9] J. Glasner, "P2p fuels global bandwidth binge," 2005. [Online]. Available: http://www.wired.com/techbiz/media/news/2005/04/67202

[10] G. Goldszmidt and Y. Yemini, "Distributed management by delegation," *icdcs*, vol. 00, p. 0333, 1995.

[11] L. Z. Granville, D. M. da Rosa, A. Panisson, C. Melchiors, M. J. B. Almeida, and L. M. R. Tarouco, "Managing computer networks using peer-to-peer technologies," *Communications Magazine, IEEE*, vol. 43, no. 10, pp. 62–68, 2005.

[12] J. O. Kephart and D. M. Chess, "The vision of autonomic computing," *Computer*, vol. 36, no. 1, pp. 41–50, 2003.

[13] A. Kovacevic, S. Kaune, N. Liebau, R. Steinmetz, and P. Mukherjee, "Benchmarking platform for peer-to-peer systems," *it - Information Technology*, vol. 49, pp. 312–319, 2007.

[14] M. Leitner, P. Leitner, M. Zach, S. Collins, and C. Fahy, "Fault management based on peer-to-peer paradigms; a case study report from the celtic project madeira," in *Integrated Network Management, 2007. IM '07. 10th IFIP/IEEE International Symposium on*, P. Leitner, Ed., 2007, pp. 697–700.

[15] C. C. Marquezan, C. C. Marquezan, C. R. Paula dos Santos, E. M. Salvador, M. J. B. Almeida, S. L. Cechin, and L. Z. Granville, "Performance evaluation of notifications in a web services and p2p-based network management overlay," in *Computer Software and Applications Conference, 2007. COMPSAC 2007 - Vol. 1. 31st Annual International*, vol. 1, 2007, pp. 241–250.

[16] C. C. Marquezan, C. R. P. d. Santos, J. C. Nobre, M. J. B. Almeida, L. M. R. Tarouco, and L. Z. Granville, "Self-managed services over a p2p-based network management overlay," in *2nd Latin American Autonomic Computing Symposium (LAACS 2007)*, Petropolis - Rio de Janeiro - Brazil, 2007, p. 7.

[17] S. Naicken, A. Basu, B. Livingston, and S. Rodhetbhai, "A survey of peer-to-peer network simulators," in *The Seventh Annual Postgraduate Symposium*, Liverpool, UK, 2006.

[18] A. Panisson, D. Moreira da Rosa, C. Melchiors, L. Zambenedetti Granville, M. J. Bosquiroli Almeida, and L. Margarida Rockenbach Tarouco, "Designing the architecture of p2p-based network management systems," in *Computers and Communications, 2006. ISCC '06. Proceedings. 11th IEEE Symposium on*, 2006, pp. 69–75.

[19] C. Simon, R. Szabó, P. Kersch, B. Kovács, A. Galis, and L. Cheng, "Peer-to-peer management in ambient networks," in *15th Mobile & Wireless Communications Summit*, Myconos - Greece, 2006.

[20] R. State and O. Festor, "A management platform over a peer to peer service infrastructure," in *Telecommunications, 2003. ICT 2003. 10th International Conference on*, vol. 1, 2003, pp. 124–131.

[21] F. Yang, S. Zhan, and F. Shen, "Psmi: A jxta 2.0-based infrastructure for p2p service management using web service registries," in *Grid and Cooperative Computing*. Springer Berlin / Heidelberg, 2004, vol. Volume 3032/2004, pp. 440–445.