

Introducing Peer-to-Peer (P2P) in Healthcare

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Abstract

Advances in technology are enabling building blocks for future IT solutions. One of them is the Peer-to-Peer (P2P) paradigm. The notion of P2P describes a class of distributed, dynamic, re-organizing systems, means to empower the user on multiple levels of work and to implement systems that use idle resources on the "edge of the net". This facilitates services and enables a complete new way of collaboration and resource sharing. Major software companies are doing research on the field of P2P as it potentially solves a couple of problems of today's health information systems. Even if media industry is challenged massively by the P2P paradigm, the healthcare sector is yet slightly touched by the P2P paradigm: only few systems are available serving as a prove of concept.

The paper outlines P2P technology and its possible impact in the healthcare domain. If the character of P2P is understood, healthcare (biomedical research, electronic health records, communications, and other fields) will benefit from using it. But it doesn't work in all cases. The underlying problems are solved „quite good“, when the paradigm fits – independent of the domain. The P2P paradigm will change today's healthcare systems in various ways. This paper will describe some cornerstones of the P2P paradigm and explain their usage in healthcare systems.

Lessons Learned from The Napster Case: The Immense Power Of P2P

Music media industry faced a big challenge during the last years. The combination of the MP3 music data format in combination with advanced networking abilities of modern programming languages and an increase in available bandwidth to the

end user made it possible to share pieces of music just as easy as writing an email or downloading a program from a website. For quite a long time the music industry didn't realize the threat for its traditional business model. When the tremendous impact of the P2P paradigm was realized, it was much too late: nearly every modern song was immediately available for free download on the P2P music exchanges like Napster [1] or Gnutella [2]. Each member of this virtual community offered very little to the common goal but these small contributions resulted in a very efficient way to move files from one computer to another, with or without using central system component. It circumvented the traditional business structures in a way that threatens the complete music business. Other well known P2P applications[3] use the idle CPU time of (client) computers to perform complicated computations (signal processing [4], weather, mathematical problems, pattern matching). In general P2P applications deal with communications, collaborations and sharing resources [5, p. 23], [6]. The systems are distributed in a way that a central server is not needed any more – every "peer" has the same capabilities, being it acting as a client or at the same time as a server ("Servent"- concept). This architecture resembles to the somehow „chaotic“ structures of real world communities [7] and offers each of the members (the peers) an increase in possibilities and performance. The media P2P case shows that using the P2P paradigm in a correct way offers enhancements to established systems. From the users point of view, using P2P systems results in a superior performance of the overall system. It is interesting that the service provider can offer better service with less resources: much of the work is done by the peers themselves.

The case of Napster [1](P2P system with a central component) and Gnutella [2] (P2P system without central components) has

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been analyzed well [e.g. 8]. The “lessons learned” can be used to critically compare the changes in the music industry to other domains. In general, the P2P paradigm challenges existing systems (infrastructure, organization, business model, ...). Only if the lessons learned from the known cases are assessed correctly, the P2P paradigm can be controlled to offer superior effects in other fields, e.g. like in management sciences or in this case in healthcare.

Defining Peer-to-Peer

When talking about Peer-to-Peer systems, it strongly depends on the personal context, what is understood by that notion since there is no strict definition of Peer-to-Peer [6, p.71] and no sharp borderline to non-P2P systems. In general most definitions [9],[10] rely on the technological features of the discussed systems. But this doesn't result in a consistent and proper definition. In most cases sharing of CPU power (e.g. SETI@home [4], Intel cure project [11]) are typical Client/Server applications from a technological point of view and hence not of P2P type, but are commonly considered to be. This arises from the fact that the overall task of one client is processed by a lot of servers. This is one reason why technology based definitions are generally not sufficient.

If we have a notion of “sociological kind of P2P applications”, meaning that the peers belong to a community that globally works on a task, we can extend those pure technical explanations. Especially powerful concepts like informally organized self-help groups belong to the success factors of P2P systems.

A third domain that has to be mentioned to form a holistic comprehension of P2P is the economical view[12]. It includes the economical impact of the change of existing systems (markets, value chains). This view particularly mirrors community effects that are important driving forces in the different socio-technical networks.

Summing up, we have to mention technological, sociological and economical effects of the P2P paradigm to understand the phenomenon. Depending on the domain, the focus varies. And even still other aspects

(like a juridical perspective) can get into the focus, too.

Is P2P an issue In The Healthcare Sector?

Healthcare systems are facing a big challenge by the increasing digitalization of the domain. More and more patients are used to use the possibilities of the internet [13], [14]. They demand for efficiently working infrastructures for a better support of the healthcare processes.

It is no question that P2P has an impact on the healthcare sector [5, Chapter 15] as first P2P systems are already running. Even if some conditions are different from the media cases mentioned above, we find similar structures like Communities of Practice (physician, nurse, pharmacy), the need to exchange files (prescriptions, healthcare data records, 2D and 3D images, billing data), to communicate securely and collaborate (second opinion) and so on. Client/Server solutions are commonly viewed as only partly resulting in sustainable solutions.

Systems in the field of healthcare are based on similar pillars like the P2P systems: technology, sociology and economics and so we can translate findings from existing P2P cases to new healthcare systems. Even if mentioning other concepts like trust or reputation, we have to consider a use in the healthcare domain [15]. Of particular importance in understanding the application of P2P systems is the role of the central provider of a service. Traditionally it was the center of the system and had to announce, start, run and maintain the service. Within the P2P paradigm, there is no need for a central maintainer of the service any more. Each peer is doing the house-keeping itself. Comparable to real life, some nodes are better cared of, some less, some offer more to the system than they pull from the network, others more or less only exploit it and do not contribute. This last case commonly is called “free-riding”[16].

Free-riding is a good example to look at when porting the P2P cases to other domains: one can learn from a problem in one domain to avoid it in the other context: Offering the patient a superior treatment based on a comprehensive, fast to access

and easily to integrate access to his patient record and access to up-to-date global knowledge will be accepted as a reason to offer new services [17]. Using P2P systems is not reduced to the patient but there will be reasonable systems supporting physicians, pharmacists, researcher and so on.

In the next section some examples of using P2P systems in the medical domain are sketched. They are not standard examples like known from biomedical research (protein folding, gene sequencing) but are more related to the patient-physician relation and electronic healthcare records.

Examples of P2P Systems in Healthcare

This section explains a few systems that adopt P2P aspects in the healthcare domain.

The first case considers „patients” that form a group of peers. Health portals with a forum / chat corner resemble the way of how P2P software can be used. Think of building reputation of the primary care physician in the patient community [5, chapter 16]: by using P2P software: opinions will be gathered on an application where the patients can discuss illnesses and treatments, can exchange opinions about the physician, about its office etc. This kind of community support will increase knowledge on the patient side since there is an open information pool that can be used by the patients (e.g. when choosing a physician) and - of course - by the physician (he will use it as a means to get feedback on his work). This second functionality is often neglected. The availability of such tool will result in better transparency on the market of health. The patient is not only dependent on the personal opinion of a few acquaintances but has access to an opinion that is based on a much broader audience. This is only one single aspect of enabling the patient with a „P2P means“. The relation of community informatics systems to the P2P paradigm is currently under research as there might be strong links between them.

If considering the eHealth issues like „reliability“, „completeness“, „patient empowering“ or the „informed patient“, especially when considered with the question of costs, the physicians could take advantage of the

P2P paradigm. Think of a scenario where a patient asks the physician to comment on an article from a newspaper. Probably this physician is not the first to answer the question, but in general he is not able to get this answer. So, when using P2P knowledge management systems, one could easily put the answer into the forum, where a general professional opinion could be discussed and published. This would be a possibility for the community of physicians to tackle the increasing information flood and hence offering a superior service in today's world of information overload.

When talking about P2P, it must be analyzed if the media case of Napster / Gnutella can be directly translated into the domain of interest [18]. In healthcare, this means for example that different hospitals and physicians offer data of a patient and the actually treating physician can combine the pieces of information from these different sources into one integrated view on the patient. One can consider such a system to be a distributed electronic patient record ([19]). Seminal work is related to Freenet [20]. That is a Gnutella-like pure P2P system (no central entity is used) that stores data encrypted and anonymously and – just to mention another feature- splits it up into different pieces that generally are not held on the same peer. So the retrieval of a document needs to combine different parts of it that on their own are not usable in any way. Each piece of demanded data is pulled from the peer where it is actually stored on the demanding peer. This is equivalent to a physical moving of document copies from one physician to another (e.g. when the patient moves). The access to the data is much faster, when the „new” physician accesses the data a second time.

One (still unpublished) P2P project of this type is currently under development in Northern Germany: it will use a central index to store meta data from the health record and will allow other registered health professionals to access data stored on the computers of the peers. The access is logged likewise. Physically there will be a special computer (always online) in each physicians office that serves as a gateway into the secured P2P network. The main target of this network is enabling an electronic data exchange in daily routine work (e.g. as a

way to implement the digital prescription) and in the case of emergency. It is a safe system (according to today's standards) and even if not every information is accessible in it, the system will improve the normal healthcare processes considerably.

This project belongs to the field of Grid applications that are probably are the most promising applications of P2P type in healthcare at this moment. Even if in this field exist many issues, too (security, merging of different data chunks, patient participation, etc.), there are a couple of tasks (e.g. image and biosignal processing) that can be solved on a grid more efficiently [21,22]. Commonly work-arounds help to overcome the existing problems. These grid applications are more oriented towards technology than the sociology oriented P2P systems mentioned before that have to deal with other, often irrational effects.

As mentioned above, there are medical P2P systems designed, implemented and running [5]. Common to all scenarios is the need for an in-depth understanding of the characteristics of P2P paradigm, the new way of using it and the astonishing performance of the overall systems.

Conclusion

P2P is a new paradigm that offers superior new possibilities in many domains, including healthcare. The cases of Napster and Gnutella offer valuable help in analyzing and designing new software and hardware systems whose technical, sociological and economical architecture are based on the P2P paradigm. SETI@home enables for intense usage of remote resources (c.f. Grid applications, [23]). The P2P characteristics offer a couple of new solutions but -of course- do not solve all problems in the healthcare domain. There often exist P2P solutions to those general problems but they have to be evaluated if they also fit to the needs of healthcare.

As there exist already healthcare related cases, healthcare is and will be a domain for P2P solutions. Depending on how the different communities are using the P2P systems, it could be a threat or benefit for the stakeholder – being it the patient, physician or another member of the system. Besides those systems for (bio-)medical research and the more technical grid applications, the biggest benefit will probably arise from using it in the field of electronic health care records, as this problem fits well to the P2P paradigm. Nevertheless not all open issues will be solvable by applying the P2P paradigm.

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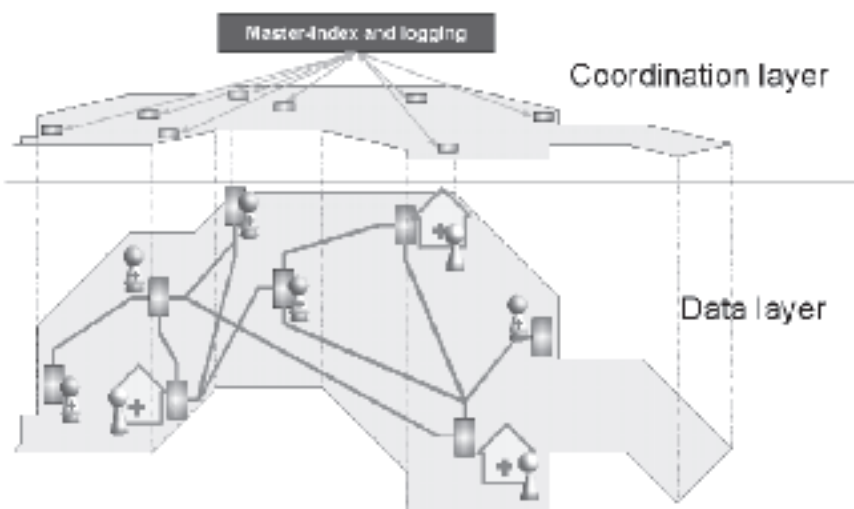


Fig. 1: Simplified example of a healthcare network using a modified Napster technology: Coordination is based on an overlay network with a central repository that links to the different providers. Data is exchanged on a peer-to-peer base, hence storage of data and the transmission load is distributed among all participants.



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