What is peer to peer ?

P2P in some sense is decentralization – moving away from monolithic central hub-spoke model to the decentralized device to device or service to service model. The devices can be edge devices or they could be servers talking to each other to make a server overlay. Even though traditional definitions of P2P include similar devices at the edges communicating without *any* central system, I think the hybrid model works best in practice. There would be some central functions like registries of all sorts, aggregation and routing.

One of the main reasons for the hybrid model is the security – identity management, authentication and authorization cannot be done in a global scale, they have to be domain or realm based one way or another. Another reason is the scale of influence of the meaningful applications – for example a medical image P2P network would be interesting only to a specialized group of neuro-scientists and possibly a well defined group of physicians.

At the O'Reilly's P2P site, the essential aspects of P2P networks are temporal and unstable connectivity and "significant autonomy at the edges". Server overlays and connected devices of all sorts satisfy these requirements.

The P2P substrate has synergies with middleware and also the much hyped, emerging area of web services.

Models of P2P Communications

Three models of P2P communications have evolved over time.

- The first and traditional model is pure P2P where two arbitrary edge devices (could be clients or servers) talk to each other without any one central device.
- A second model is a partial reliance on a central service. Applications such as instant messaging and Usenet have a reliance on central service for user association with configuration settings and propagating information in a hierarchical fashion respectively.
- A third model that has recently evolved is federated P2P where the peer to peer communications occur in the realm of domains – be they be inside a corporation or a campus infrastructure in an educational institute.

From Internet2 perspective the Federated Model offers many synergies.

Federated P2P

The features of a federated P2P include

- Identity management based on a directory infrastructure
- Cross domain identity, authC and authZ management based on domain membership
    - For example physicists across different educational organizations might collaborate at a p2p level but based on their membership in their federated domain. In this case all the fellow physicists in one educational institution would be peers in a domain and all physicists would be a collection of peers from multiple domains.
- Limited number of resources to share – storage, devices or content
- But dynamic content which could also be graded based on some criteria

P2P Security

P2P networks are not just about communication between devices onthe wire - security is a prerequisite for many of the meaningful interactions and scalability in the p2p world. In addition to the traditional security primitives like Confidentiality, Integrity and Availability, factors like privacy, DRM and identity management are fundamentally required to make a P2P network effective.

DRM and the next level abstraction - policy (and role) based authorization - is a P2P native paradigm.

[2] articulates a few security advantages particular to P2P systems.

1. Privacy :
   Since a message can be sent between two peers without going through a centralized server, there's no way an intruder on the server can read the message.

2. No Central Point of Knowledge
   Since content can be replicated un-deterministically anywhere on a P2P network, it's impossible for an intruder to know the location of all copies. As a result content corruptions and denial-of-service attacks can't be performed that easily on a Peer-to-peer network.

3. Web of Trust
   When interacting with each other, peers can establish their own level of trust. In a federated P2P environment, this can be achieved by the trust

established between the domains. P2P systems then can refine the general trust level to suit their interactions.
For example school A might not allow school B to access all it's contents but a CS professor in A might allow a CS colleague from B to access one's research materials they are collaborating on.

4. Locality
When searching, a peer will always ask another peer in its local domain first. As a result, bad behavior is limited to neighbors or direct contacts. When a server is contaminated, so are all its clients.

P2P Applications

There are many applications for P2P networks:

- Content distribution over a P2P network is a viable and honorable model in many cases – for example the OpenOffice group in Sun is looking for a P2P network to ease downloading of their software. Even though file sharing itself has been shadowed by the publicity around ad-hoc music file sharing networks, the concept can be effectively used to share content across various populations for various reasons – from digital image assets (like photograph) between friends and relatives to sharing of medical images with shared annotations. From a security perspective, these apps require integrity of content, content versioning, confidentiality in the content sharing medium and authorization to view the content.

- Distributed search is another application that can be leveraged by a P2P network. In this application peers know some part of the search domain and work at keeping the meta information like indexes fresh [3]. [4] talks about PeerOLAP architecture where a number of low-end clients, each containing a cache with the most useful results, are connected through an arbitrary P2P net-work.

- Collaborations at many levels are possible based on federated P2P networks. We can easily think of collaborations for designing autos, planes or any such systems. These systems require direct interactions between entities and also content sharing between those entities.

  Collaborations facilitated by a P2P network can be personalized as well. An example is a skills database that lists expertise associated with an individual such as a campus academic advisor and their contact information. A studious student (are there any other kind ? :0)) might want to ping somebody in the middle of night to understand some

mathematics problem for MCAT; another student might be looking for somebody to explain the Nigel's algorithm

- At a personal level, at home we all have come across devices that are at a different computer than the one we want. P2P networks could help here - for example a fast CD burner could be accessed via P2P network from any other computer in the network

- Other potential areas where federated P2P can be applied include :
  - Server overlays
  - First responder networks
  - Self organizing networks
  - Ad-hoc networks
  - Spontaneous networks

Ideas for future

Internet2 offers unparalleled opportunity for the P2P domain. As a part of the I2 infrastructure, we should make P2P frameworks and substrates available which includes one or more P2P eco systems consisting of various "devices" including Peer registry (dynamic/static), Peer router and Peer monitor.

We also should seek synergy from the enterprise space has a lot of applications for the federated P2P networks.

Another thought we have is to see if we can sponsor graduate or undergraduate P2P projects based on the I2 infrastructure – either corporate projects or project from the faculty.

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