Introduction Distributed Systems

Today
- Welcome
- Distributed systems definition, goals and challenges
What is a distributed system?

- **Very broad definition**
  - Collection of components, located at networked computers, that communicate & coordinate their actions only by passing messages

- **Why do you want one?**
  - Resource sharing, computation speedup, resilience, people interaction

- **Implications**
  - Concurrency – concurrent execution is the norm, concurrently executing processes must be coordinated
  - No global clock – coordination often depend on the notion of time but there are limits to clock synchronization
  - Independent failures – multiple and independent failures, sometime even hard to recognize them as such
Example classes of distributed systems

- **Distributed computing systems**
  - Clusters – set of similar off-the-shell workstations, running their own OS, interconnected by a high-speed LAN
  - Grids - each part potentially under a different administrative domain, hardware/software/network

- **Distributing information systems**
  - Distributed transaction systems
  - Enterprise application integration

- **Mobile and ubiquitous computing**
  - Small, networked devices are now part of distributed systems
  - Devices small enough to go unnoticed become part as well
Distributed systems challenges ...

- **Heterogeneity**
  - Systems are built from a variety of components, mask those differences

- **Security**
  - Sharing, as always, introduces security issues

- **Openness**
  - Systems should be extensible – follow agreed-upon rules on component syntax & semantics for interoperability

- **Scalability**
  - In numbers (users and resources), geographic span and administration complexity
Distributed systems challenges

- **Failure handling**
  - Partial failures are hard to manage – each component may fail and must be aware of and handle other components’ failures

- **Concurrency**
  - Sharing also brings in inconsistency from concurrency

- **Transparency**
  - Hide the fact that the system is distributed
Scalability problems

- Scalability in numbers of users and resources, geographic span and administration complexity
- Scalability in numbers
Scalability problems

- **Scalability in numbers - limiting features**
  - Centralized services – a single server for all users
  - Centralized data – a single HOSTS file for the Internet
  - Centralized algorithms – routing with complete information

- **Characteristics of decentralized algorithms**
  - No machine has complete information about the system state
  - Machines make decisions based only on local information
  - Failure of one machine does not ruin the algorithm
  - There is no implicit assumption that a global clock exists
Scalability problems

- Geographic scalability – from LANs to WANs
  - Synchronous communication, where requesting client blocks until it gets a response, makes it hard to scale
  - Communication is unreliable and nearly always point-to-point
    - e.g. broadcast for locating a service doesn’t work
  - Centralized solutions are clearly an issue as well

- Administration complexity
  - Conflicting policies, with respect to resource usage, management and security, must be handled
  - E.g. Can you trust your sys admin? Can you trust users from another domain?
Scalability techniques

Three general classes of techniques for scaling

- **Hiding communication latencies**
  - Key for geographic scalability
  - How? Asynchronous communication, shipping code

- **Distribution**
  - Break up and distribute the system – e.g. Domain Name System, World Wide Web

- **Replication/Caching**
  - To increase availability, balance load and avoid communication latencies
  - The drawback – consistency
Challenges – Transparency

- Types of transparency
  - Access – What’s data representation? Access local and remote resources using identical operations
  - Location – Where’s the resource located?
  - Migration – Have the resource moved?
  - Relocation – Is the resource being move?
  - Replication – Are there multiple copies?
  - Concurrency – Is anybody else accessing the resource now?
  - Failure – Has it been working all along?

- Do we really want transparency?
  - Impossible – remote controlling a space ship
  - A bad idea – creating false expectations
  - Against application’s goals – pervasive computing and location awareness
Challenges & pitfalls

Adding to the challenges, common false assumptions

- The network is reliable
- ... secure
- ... homogenous
- The topology does not change
- Latency is zero
- Bandwidth is infinite
- Transport cost is zero
- There is one administrator
Question 1

- Use the world wide web as an example to illustrate the concept of resource sharing. Discuss two of the main challenges that must be dealt with in this context.
This class – topics

- Introduction to distributed systems
- Peer-to-peer – definition, classes, uses
  - Dealing with an imperfect Internet
  - Content distribution networks for the people
- Challenges they may help us address
  - Censor resistance
  - Preserving anonymity
- Challenges they face
  - Peers and their service providers
  - That legal issue
Course outcomes

You should be able to …

– Explain the basic technological concepts behind P2P
– Understand the potential of P2P approaches to resource sharing
– Recognize the different approaches to P2P
– Explain some of the potential implications of P2P to the business enterprise
– Discuss some short and long-term future trends as seen by industry and academic researchers in the field
Class organization - grading

• Class participation 50%
• Assignments 50%
  – Readings 15% - you will select 3 of the paper listed for the week and write a summary report, following the guideline provided in the class website
  – Short in-class questions 15% - will gather in group of 2-3 to answer a given question, come up with a common answer for the group, but any dissenting opinion will be noted properly.
  – Essay 20% - you will write a 5-page essay examining the juxtaposition of 2-3 of a list of given topics (e.g. unstructured P2P, self-adaptation, overlay multicast, censorship, …)