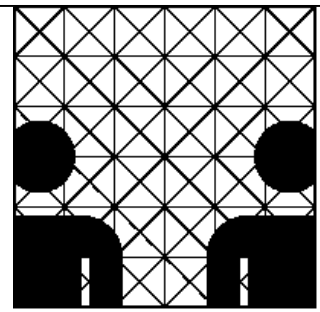


Anatomy of „The Grid“

Anatomy of „The Grid“

- Contents
  - **Part 1: What is the Grid?**
    - **1.1 Electric power Grid**
    - **1.2 Definition of „The Grid“**
    - **1.3 Impact of Grids**
    - **1.4 The Grid problem**
  - Part 2: Virtual Organisations using Grids
  - Part 3: Grid Architecture
  - Part 4: Relationships with other technologies
  - Part 5: Other Perspectives on the Grid
  - Part 6: Summary

What is the Grid?
1.1 Electric Power Grid

- „The Grid“ got its name from the electric power grid.

- Why is this a good analogy?
  - Special device was needed (electric generator).
  - Considerable knowledge needed to operate devices.

  - Consequences: usage of electricity was hindered.

Quelle: Foster - „The Grid – blueprint for a new computing architecture“, 1999

What is the Grid?
1.1 Electric Power Grid

- Why has electricity-based technology spread nevertheless?
  - Development of „Electric Power Grid“
- Benefits of the Electric Power Grid
  - Reliable
  - Low-cost-access to a standardized service
  - Power universally accessible
- Other Important Factors
  - Economics
  - Politics, not only technological innovation
  - Complexity of control

Quelle: Foster - „The Grid – blueprint for a new computing architecture“, 1999

What is the Grid?
1.1 Electric Power Grid

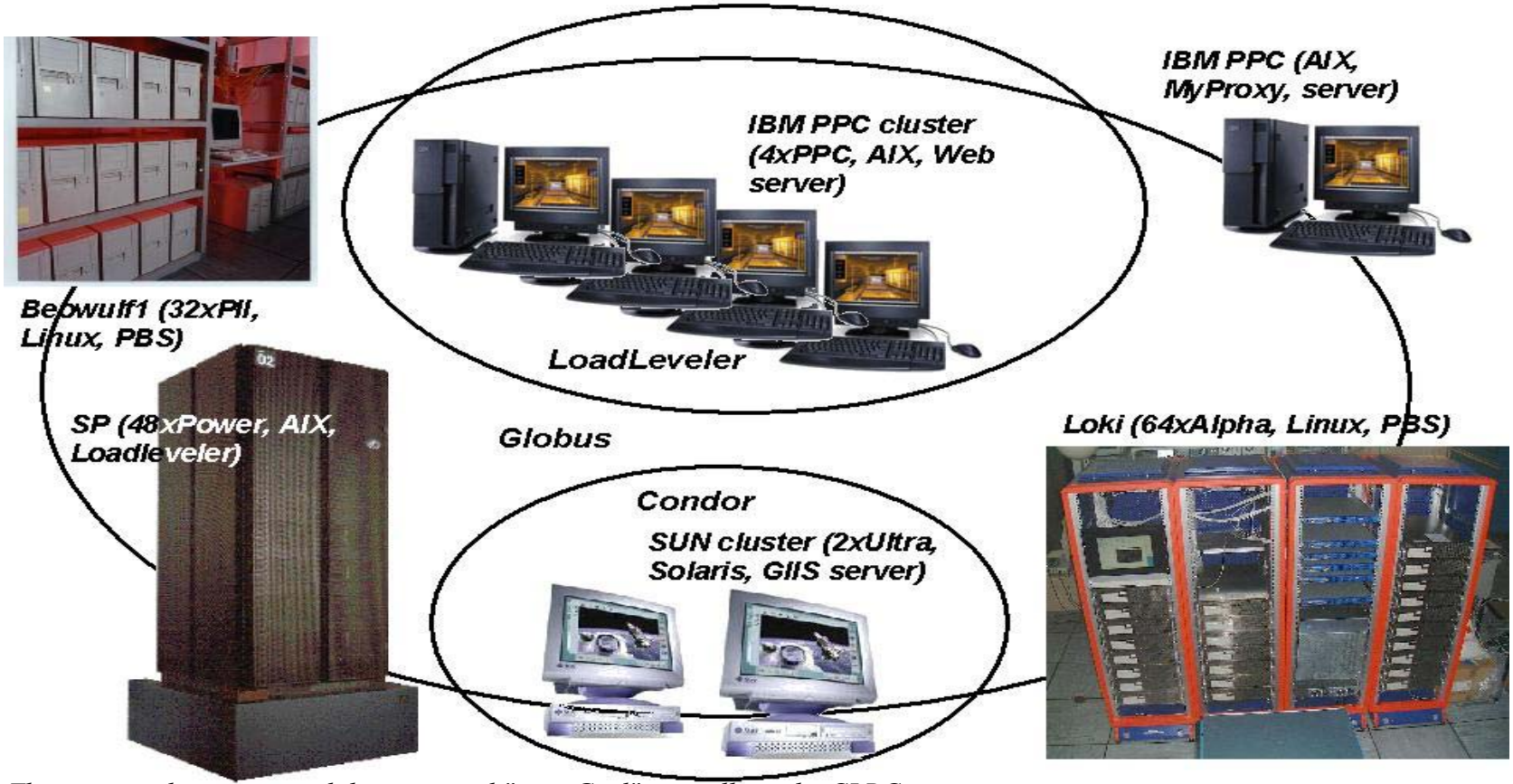
- We need some kind of “Computational Grid” which *revolutionizes the use of computing* by making the construction and use of *large scale systems of diverse resources* as easy as using today’s desktop environment?

Quelle: http://doesciencegrid.org DOE Science Grid - Website

1.2 Definition of Computational Grids
1st Definition

- „*Computational* Grid“
  - „Hardware and software infrastructure that provides dependable, consistent,
    pervasive and inexpensive access to high-end computational capabilities.“

1.2 Definition of Computational Grids
A sample Grid



This picture shows a typical departmental "mini Grid", actually at the CLRC Daresbury Laboratory.

Quelle: http://www.grid-support.ac.uk/

1.2 Definition of Computational Grids
Examining the 1st Definition

- Infrastructure
  - Grid = large-scale pooling of resources e.g. compute cycles, data, sensors, people. Distributed hardware must be structured.
- Consistent
  - standardized services accessed via standardized interfaces and operating with standard parameters (--> Globus Toolkit).
- Dependable
  - without reliable infrastructure no users will be using „The Grid“.
- Pervasive
  - services must be available in whatever environment we move.
- Inexpensive
  - Must be widely used in order to use net-effects.

Quelle Foster, Kesselman „The Grid - Blueprints for a new computing infrastructure“ Foster, 1999

1.3 The Impact of Grids

- Early Grid concepts originated 10 years ago. How far is the knowledge to develop new applications which support distributed computing and high-speed networking?
- How important is the Grid today?

1.3 The Impact of Grids
selected Grid projects

Name	URL & Sponsors	Focus
Information Power Grid	http://ipg.nasa.gov NASA	Create and apply a **production Grid** for aerosciences and other NASA missions
Earth System Grid (ESG)	**earthsystemgrid.org** **DOE Office of Science**	**Delivery and analysis of large climate model datasets for the climate research community**
European Union (EU) DataGrid	eu-datagrid.org European Union	Create & apply an operational grid for **applications in high energy physics**, environmental science, bioinformatics

1.3 The Impact of Grids
Earth System Grid

- www.earthsystemgrid.org
- Global coupled earth system models
- Models need and produce very large amounts of data (terabyte level)
- Results will be free for participating Organizations
- Organizations can use the services independently.

1.4 The Grid problem

- Is there something like a typical „Grid Problem“?

- The „Grid Problem“
  - How to use controlled and coordinated resource sharing and resource use in dynamic, scalable virtual organizations?

Quelle: Foster, Kesselman, Tuecke „Anatomy of the Grid“, 2001

1.4 The Grid problem 1

- Resource sharing
  - Computers, storage, services, sensors, …
  - Sharing always conditional: issues of trust, policy, negotiation, payment, …
- Coordinated problem solving
  - Beyond client-server: distributed data analysis, computation, collaboration.
- Dynamic, multi-institutional virtual orgs
  - Community overlays on classic org structures
  - Large or small, static or dynamic

1.4 The Grid Problem 2

- Enable communities (“virtual organizations”) to share geographically distributed resources as they pursue common goals -- *assuming the absence* of…
  - central location,
  - central control,
  - omniscience,
  - existing trust relationships.

Anatomy of „The Grid“

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    - **2.3 Problems**
    - **2.4 summary**
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2. Virtual organizations in the Grid-context
2.1 Definition

- „Virtual Organization“
  - The collection of geographically distributed, functionally and culturally diverse organisational entities linked through information and communication technologies.
- Characteristics (each more or less)
  - Virtual in concept
  - Highly flexible
  - Dynamic
  - Temporary

Quelle: Erastos Filos (European Commission), „Virtual Organisations“, 2000

2. Virtual organizations in the Grid-context
2.2 sample scenarios

- Scenario 1
  - Industrial consortium
  - Development of an aircraft study
  - Highly accurate simulation
  - The parts of the simulation are developed on each participants ressources

2. Virtual organizations in the Grid-context
2.2 sample scenarios

- Scenario 2
  - Thousands of scientists worldwide
  - Analyzing the results of a really expensive device
  - Pooling of resources
  - Creating a „Data Grid“

2. Virtual organizations in the Grid-context
2.2 sample scenarios

- Differences
  - Number and type of participants
  - Duration and scale of interaction
  - Resources shared
- Things in common
  - Sharing of resources in order to achieve a goal.
  - Can involve direct access to software, computers, data...

2. Virtual organizations in the Grid-context

2.3 Legal problems in the EU

Problem	Solution
Electronic tracking of responsibility and liability	Development of new software
Evidence from e-documents having legal force	NEW EU-directive to make it legal.
Sample contract clauses for digital environment	Legal draft exists in the EU
Software to support legal issues	Development of new software + new laws

Quelle: Erastos Filos (European Commission), „Virtual Organisations“, 2000

2. Virtual organizations in the Grid-context
2.3 Problems

- What „the Grid“ offers:
  - Security solutions that support management of credentials and policies.
  - Resource management protocols and services that support **secure remote access to** shared **computing and data resources** and the co-allocation of multiple resources.
  - Information query protocols and services that provide **configuration and status information** about resources, organisations and services.
  - **Data management** services that locate and transport datasets between storage systems and applications.

2. Virtual organizations in the Grid-context
2.4 Summary

- VO are key indicators of the shift from industrial to the digital era.
- Big problem of modern information technologies:
  - Technology and innovation alone won‘t be sufficient.

Quelle: Erastos Filos (European Commission), „Virtual Organisations“, 2000

Anatomy of „The Grid“

- Contents
  - Part 1: What is the Grid?
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  - **Part 3: Grid Architecture**
    - **The Nature of Grid Architecture**
    - **Description**
    - **In Practice**
  - Part 4: Relationships with other technologies
  - Part 5: Other Perspectives on the Grid
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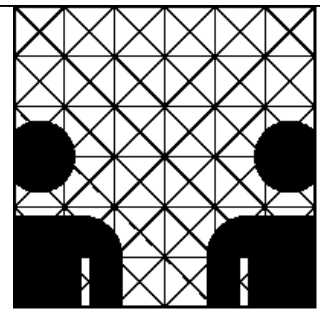


Basic of Grid Computing

„ The Anatomy of the Grid “

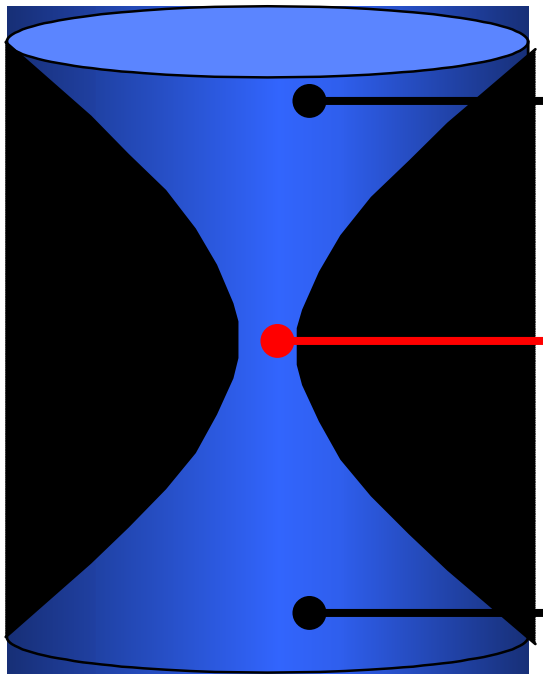
Grid Architecture

- The Nature of Grid Architecture

- Protocol, Service, API & SDK
- Interoperability is the central issues in Grid
- In a networked environment, interoperability means common protocols
- Grid architecture is a protocol architecture
- Service is defined by the protocol and behaviors
- Standart services allow us to enhance the service offered to VO participants
- API & SDK for sophisticated application in grid environments

Grid Architecture

- Grid Architecture Description



Application and Collective Layer

: construct a wide range of global services and application-specific behaviors

Resource and Connectivity Protocol

: small set of core abstractions and protocols

Fabric Layer

: defined the diverse rage of resource types

Grid Architecture

- Grid Architecture Description „Fabric“

- **Fabric :** Interfaces to local control
  - Provides the resources to which shared access is mediated by Grid protocols.
  - *Globus Toolkit*
    - Designed to use existing fabric components.
    - Implement standart Grid protocols and APIs
    - Open source

Grid Architecture

- Grid Architecture Description „Connectivity“

- **Connectivity :** Communicating easily and securely
  - *Communication* : enable the exchange of data between Fabric layer resources.
  - *Security* : verifying the identity of users and resources
    - Uniform authentication & authorization mechanisms in multi-institutional setting
    - Single sign-on, delegation
  - *Globus Toolkit*
    - Grid Security Infrastructure (GSI)

Grid Architecture

- Grid Architecture Description „Resource“

- **Resource** : Sharing single resources
  - Define protocols (APIs and SDKs) for the secure negotiation, initiation, monitoring, control, of sharing operation on individual resources.
  - *Globus Toolkit*
    - Grid Resource Information Service (GRIS)
      - Access to structure & state information
    - Grid Resource Allocation Mgmt (GRAM)
      - Remote allocation, reservation, monitoring, control of compute resources
    - GridFTP protocol (FTP extensions)

Grid Architecture

- Grid Architecture Description „Collective“

- **Collective** : Coordinating Multiple Resources
  - Global in nature and capture interactions across collections of resources.
    - Directory service
    - Monitoring
    - Replication service

Grid Architecture

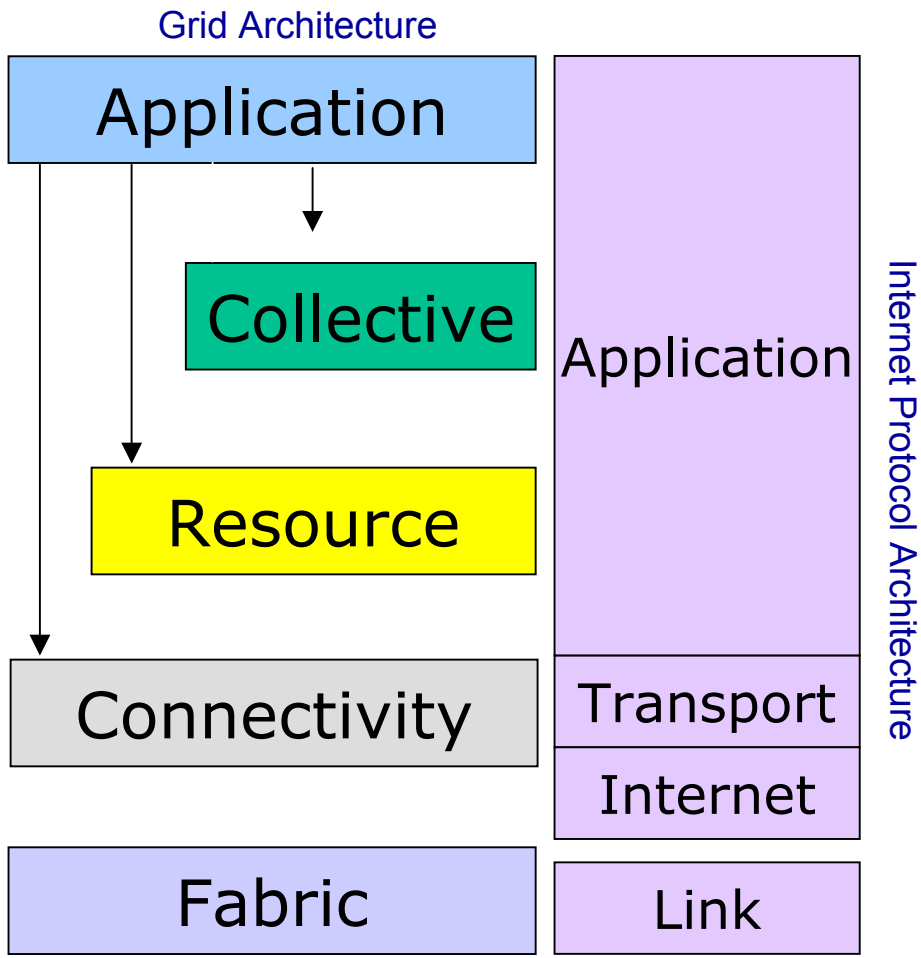
- Grid Architecture Description „Applications“

“Coordinating multiple resources”: ubiquitous infrastructure services, app-specific distributed services

“Sharing single resources”: negotiating access, controlling use

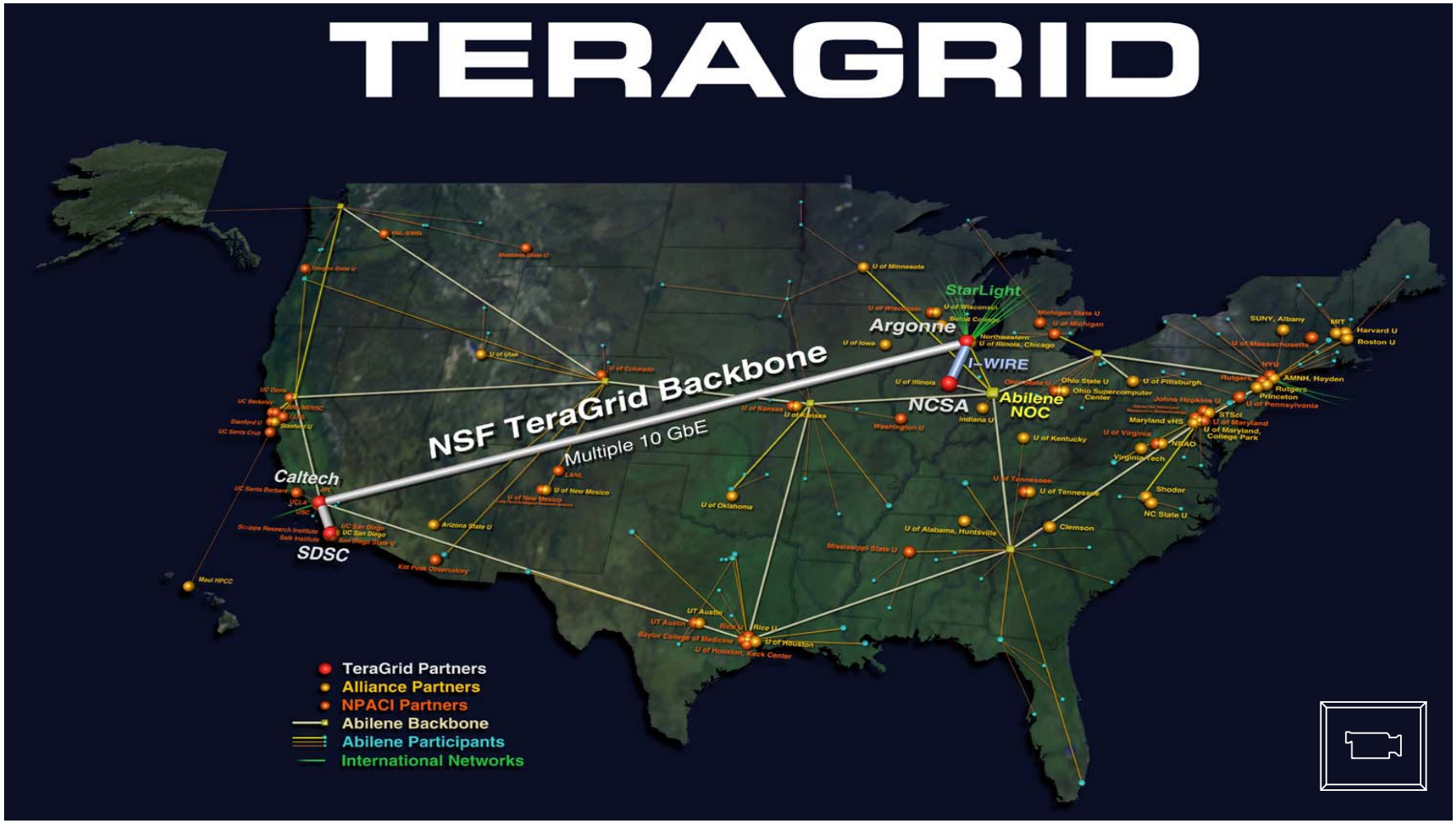
“Talking to things”: communication (Internet protocols) & security

“Controlling things locally”: Access to, & control of, resources



Grid Architecture

- Grid Architecture in Practice



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Relationships with Other Technologies

- **World Wide Web**
  - Excellent job of supporting the brower-client-to-webserver interactions
  - Integrate Grid and Web Technologies
    - Single sign-on : single sign-on to multiple Web servers
    - Delegation
- **Peer-to-peer** computing
  - Focus on data sharing techniques rather than common protocols that allow for shared infrastructure and interoperability.

Other Perspectives on Grids
-Perspectives

1. "The grid is a source of free cycles"
2. "The grid makes high-performance computers superfluous"
3. "The grid requires a distributed operating system"
4. "The grid is a next-generation Internet"

Summary

- Origin and intentions of the "Computational Grid" idea.
- The role of Virtual Organizations
- Overview on Grid and suggests Grid architecture
- Interoperability and intergrid protocol is central issue on the work
- Grid is growing and changing rapidly
- What the Grid cannot do
- Grid Security is hard

- **Grid is not implemented completely but will be come true**

Bibliography

- **The Anatomy of the Grid: Enabling Scalable Virtual Organizations**. I. Foster, C. Kesselman, S. Tuecke. *International J. Supercomputer Applications*, 15(3), 2001.
- **Grid Service Specification**. S. Tuecke, K. Czajkowski, I. Foster, J. Frey, S. Graham, C. Kesselman; Open Grid Service Infrastructure WG, Global Grid Forum, Draft 2, 7/17/2002.
- ***The Grid: A New Infrastructure for 21st Century Science***. *I. Foster. Physics Today, 55(2):42-47, 2002.*
- ***www.globus.org/research/papers.html***
- **„Virtual Organisations“,** E. Filos (European Commission), 2000
- **„The Grid – blueprint for a new computing architecture“,** Foster - 1999
- **http://doesciencegrid.org**
- **http://www.grid-support.ac.uk**