GridEcon
Grid Economics and Business Models

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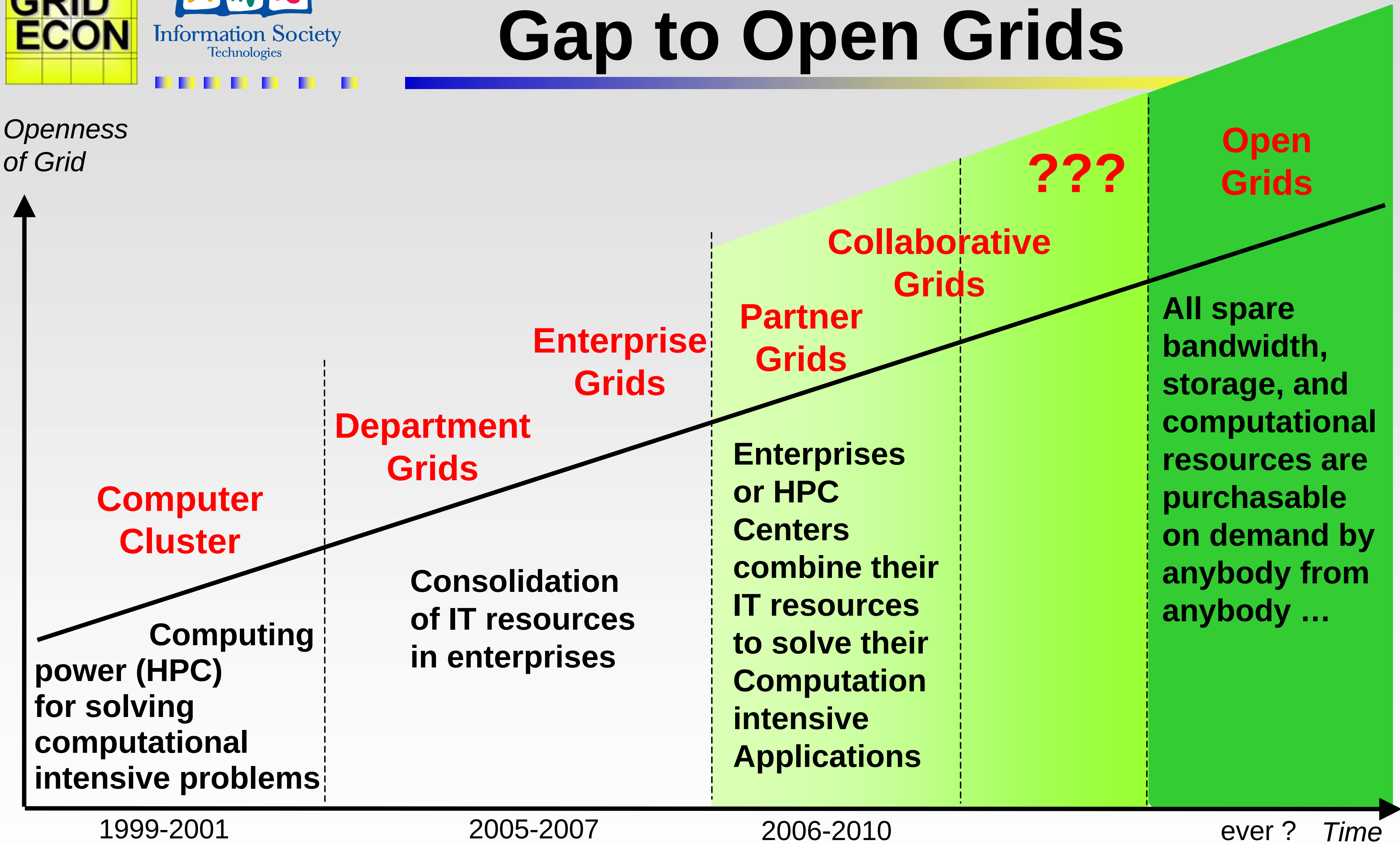
Grid Computing

- The term Grid is an analogy to the power grid, which provides consistent, pervasive, and dependable access to electricity produced from different sources at different locations
- The Grid is distributed system that enables the sharing, aggregation, and selection of resources (CPU, storage, and bandwidth) based on their availability, capacity, performance, cost, and user’s quality-of-service requirements

Motivation: Closing the Gap to Open Grids



- Classification of Grids by ownership, use, utility, type of resources (e.g. SW, HW) helps to define the “???” area

Motivation for a Project on Grid Economics and Business Models

- **There are many technical solutions for Grid computing**
  - Many open source middleware systems (Globus, glite (dgas), GRIA, Unicore, etc) have been developed
  - There are even a few commercial middleware implementations
- **But, only a few economically sustainable applications of Grid technology exist. They are**
  - In the area of **high-performance computing** and,
  - To a **limited extent, in the commercial environment**
- **What is the reason for this low take up? Are there no other sustainable business models?**

Motivation: Sustainability of Grid Computing

- **Sustainability of Grid Computing is about**
  - Finding **business model** which guarantees RoI (Return on Investment) to recover at least the cost for this new infrastructure

- **To achieve sustainability in the Grid environment**
  - **Tools for users** (researchers, organizations, companies, general public) are needed **so that users can benefit** from the Grid
    - Benefit means that there is a return on a user's investment in Grid
    - Tools (functionalities) can comprise ontology definitions, data structure updates, a **dynamic scheduler, a risk broker, capacity planning, services markets**, etc

GridEcon: Project Scope

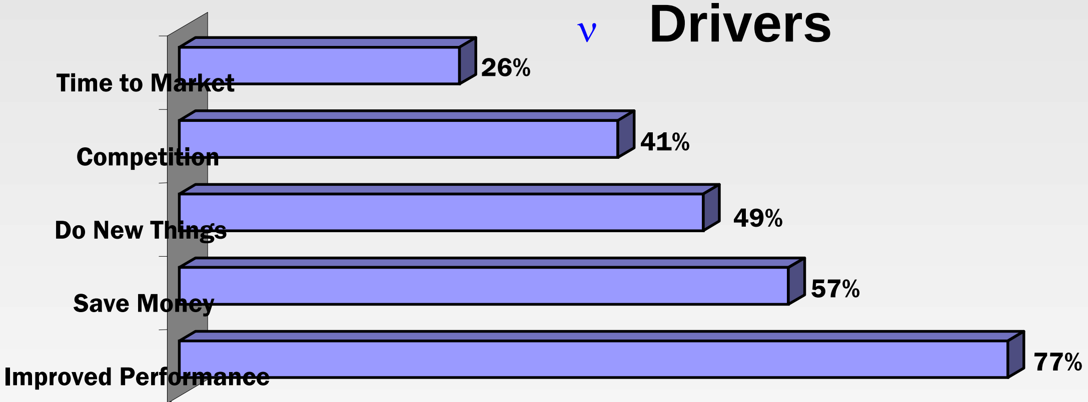
- **The goal is to advance the functionality of existing Grid technology, so that**
  - an **economics-aware operation of Grid applications and services becomes possible** (i.e. new Grid business models can be implemented)
  - **end-users can not only consume but also sell services (resources) on the Web**, therefore, creating a new economy in which all end-users can actively participate (generate income)

GridEcon: Project Facts

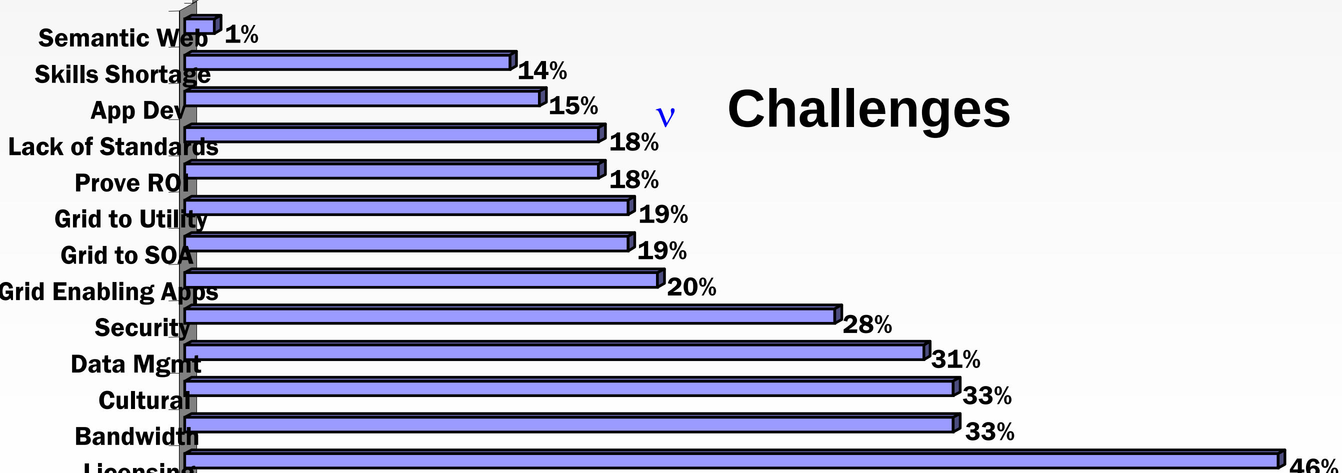
- **Title is Grid Economics and Business Models**
- **EC funded project**
  - **Addressed objective** “Advanced Grid Technologies, Systems, and Services” within the EU Sixth Framework Program, Priority IST
  - **Funding period** is July 2006 to December 2008
  - **Project size** is 3.89M Euro (EC funding is 2.35M Euro)
- **9 consortium partners**
  - **Coordinator:** Intl. University of Bruchsal
  - **Partners:** Athens University of Economics and Business, Imperial College London, the451Group, LogicaCMG, ATC, Ernest&Young, RealTimeEngineering, Gigaspaces

Outline of GridEcon Research Result

- Collected different Grid scenarios (Deliverable D1.1)
  - Drivers



  - Challenges



- Classification

Field
Scenario Meta data
Scenario name
Origin of scenario
Typical users
Kind of benefit
Alignment with EU goals
Classification
Scenario Information
Synopsis of Scenario
SWOT analysis
Complexity
Ambition
Actors / Entities in Scenario
Additional remarks
Schematic Overview
Long Scenario Description
Meta Data about Scenario Record
Author
Filled in by
Date
Remarks

Outline of GridEcon Research Results

- Analyzed the different scenarios and classified them into different groups of business models (Deliverable D1.3)

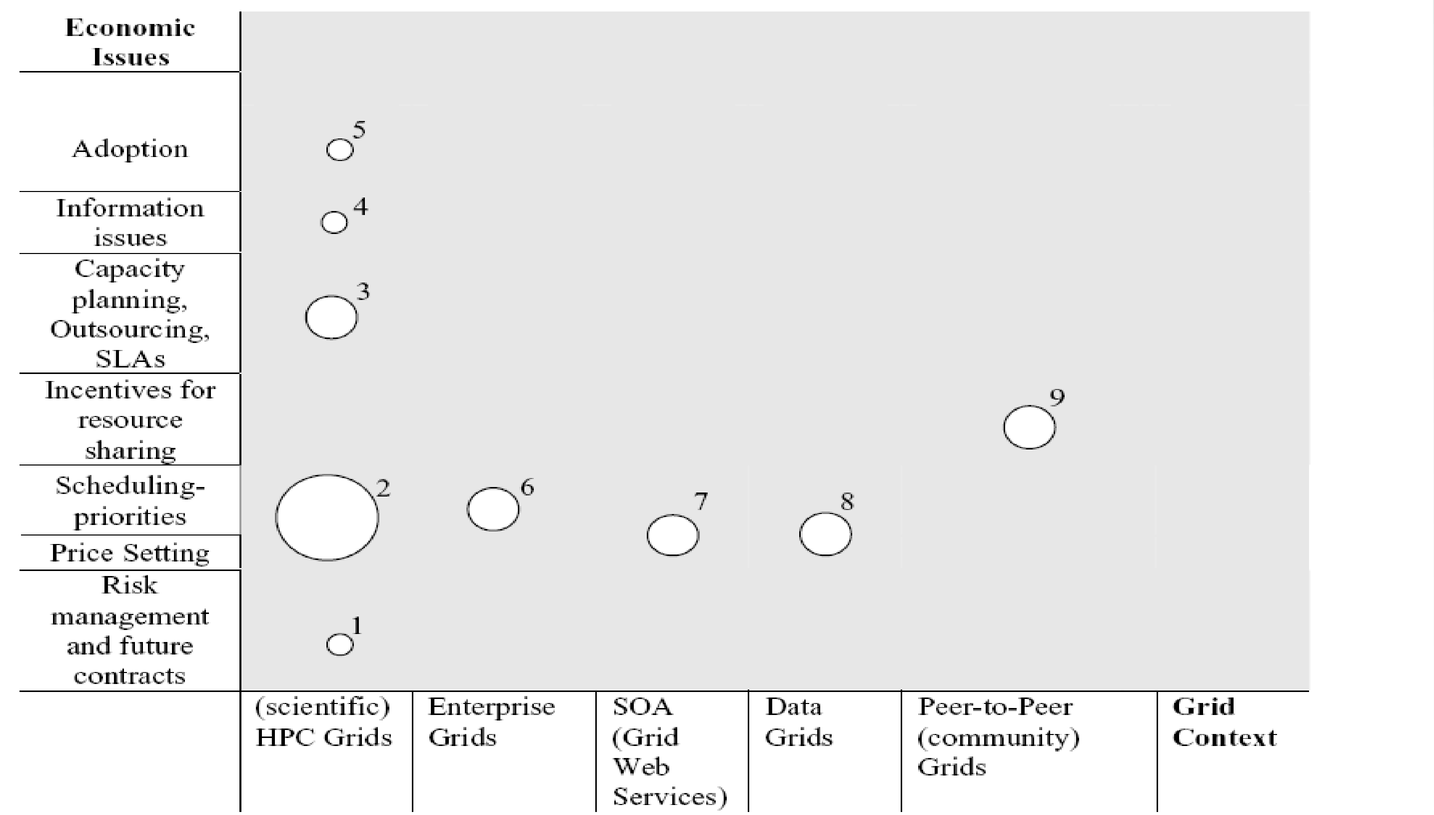
  - Ranking

Scenario	Rank
Brokerage of EC & Storage	1
DEISA	1
Financial Services	3
Exchange Monitoring	4
Business Intelligence	4
University Computing	6
Grids in Healthcare	7
BEinGrid 15	8
Order Management	8
Accessible SC for SME	8
Consumer Web Services	11
Virtual company	12
Museum	12
Squads	12
Social Network Services	15
Insurance Car Repair	16

- Rather than picking the top 3 scenarios we have chosen to focus on three types of scenarios
  - Open Market in Utility Computing
  - Intra company Utility Computing
  - Software as a Service (SAAS)

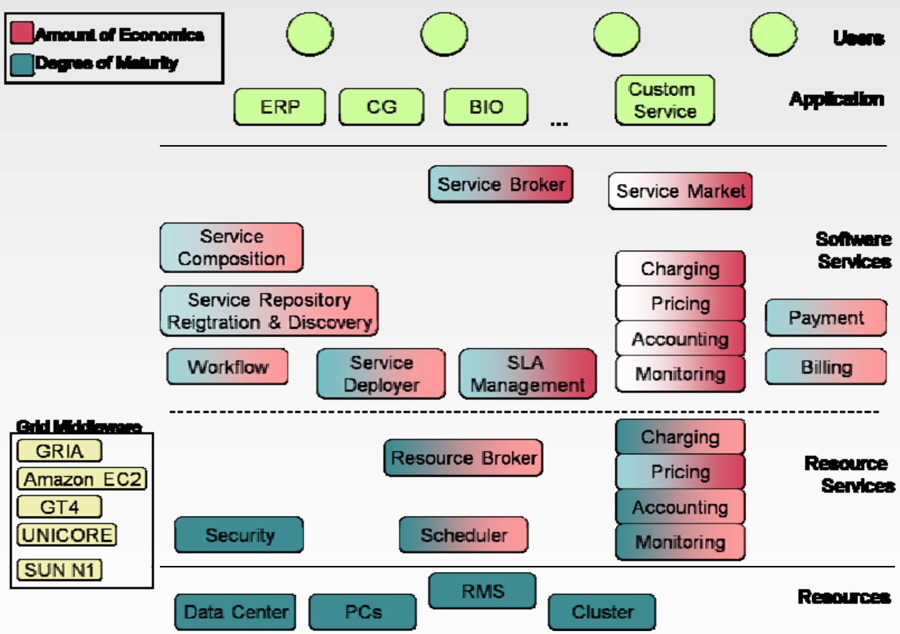
Outline of GridEcon Research Results

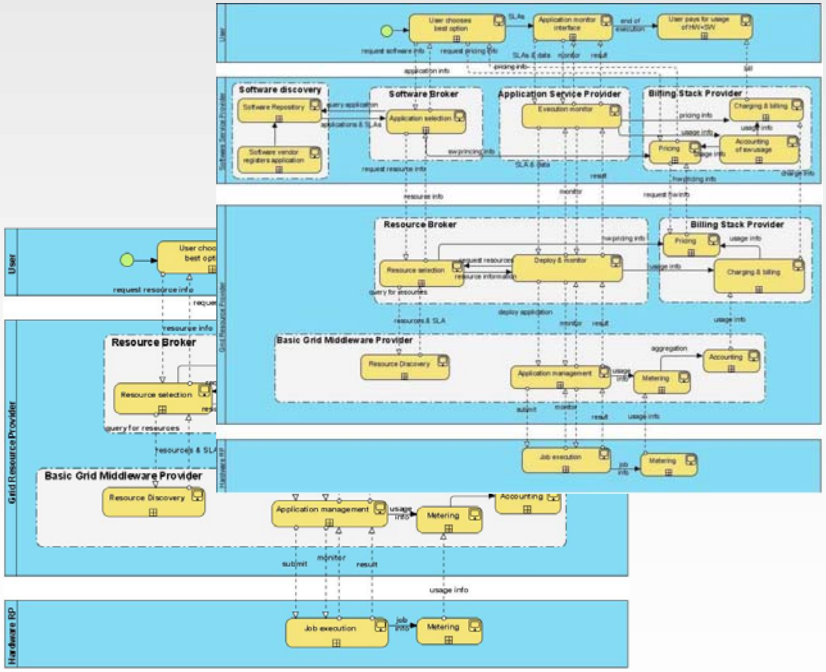
- Analyzed existing approaches to Grid economics and listed economics-related challenges for Grid computing (Deliverable D2.1)



Outline of GridEcon Research Results

- Developed a Grid Architecture based on economic-aware components (Deliverable D3.1) its dependencies





- Analyzed existing Grid technology with respect to its economics-related awareness

- Dependencies between different economic-aware components

Assumptions & Requirements: Hardware Resources

- **The Grid can be constructed out of many heterogeneous computational resources**
  - High-performance computers
  - Server clusters
  - Geographically distributed heterogeneous PCs
- **However, we believe a common resource market for these different resource types will not be possible**
  - The reason is that these resource markets require different technology (i.e. economic-aware components) for their implementations

Assumptions & Requirements: Applications

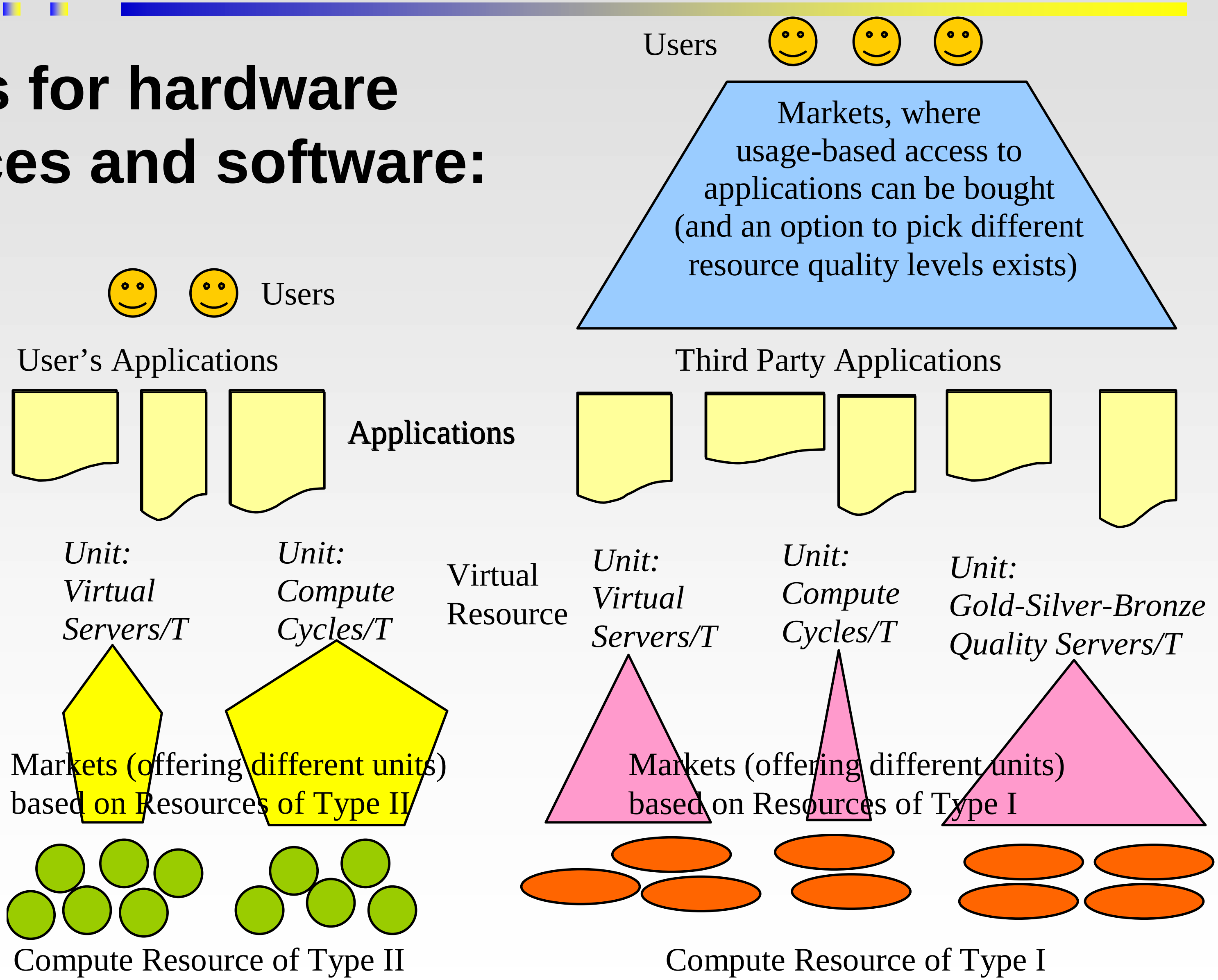
- **There are different kind of applications:**
  - Single-job, topology-dependent, profiled-load applications
  - Workflow applications (dependencies between sub-jobs of any type)
  - Web server style of applications (data parallelizable)
- **There is no single contract type for an application category**
  - Different kind of **applications require different kind of contract types** (i.e. they impose different requirements on lower layer markets)
    - E.g. Some applications (Web servers) **need fast response from lower resource markets**, other applications not at all
    - E.g. The **load of applications can range** from predictable to unpredictable
  - For simplification, we assume that only similar kind of contracts can be traded on a market

Assumptions & Requirements: End-User

- **The Grid user wants to get its own application executed**
- **The Grid user wants access to applications at best price and on a pay-per-use basis**
  - No cost of ownership
  - Access to the desired hardware resource quality level

GridEcon's Resource Model

- **Markets for hardware resources and software:**



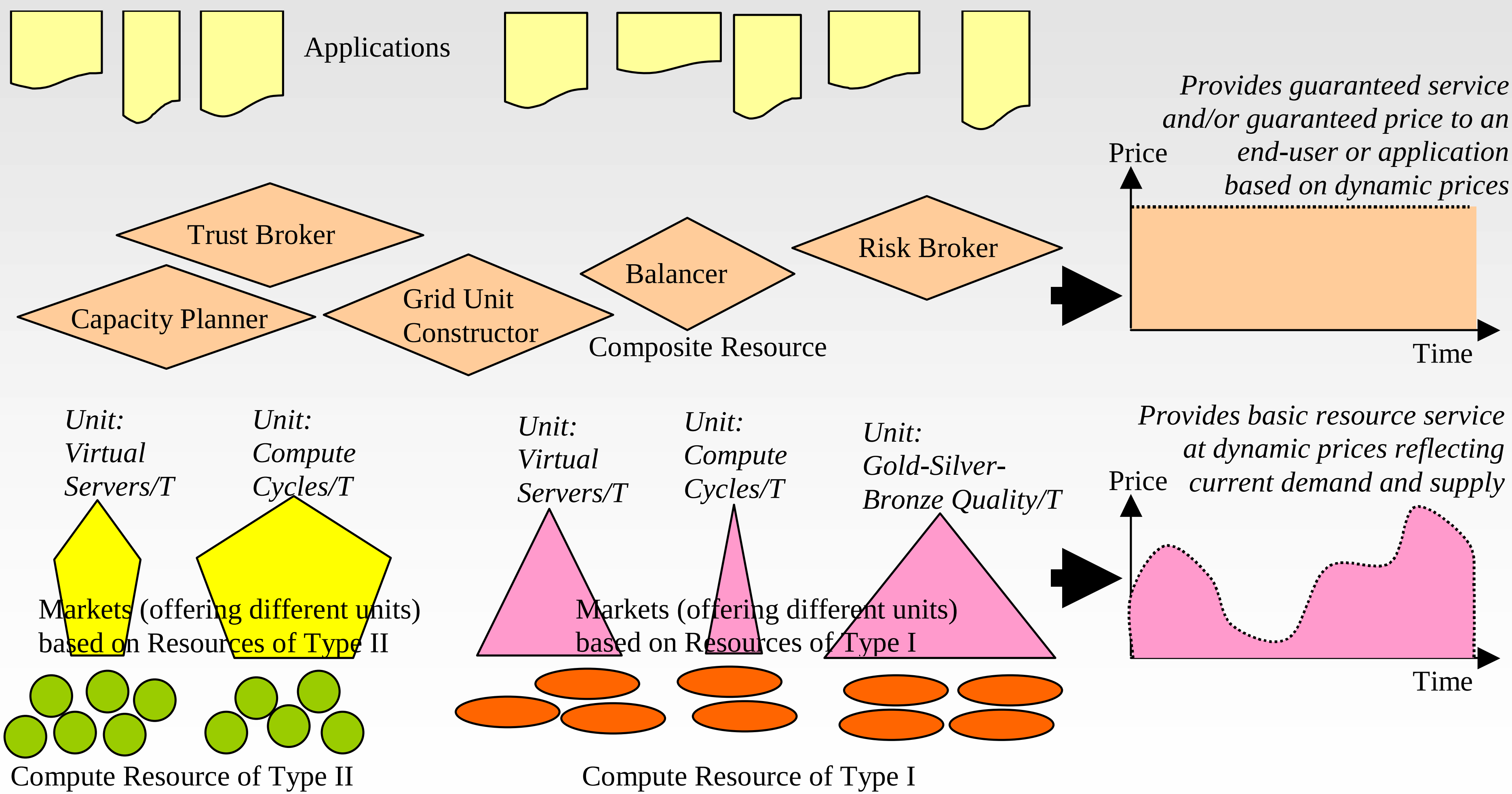
GridEcon's Resource Model: Unpredictability / Uncertainty

- **Current work on resource provisioning assumes that resource requirements can be predicted accurately and providers can guarantee service quality**
  - But, unforeseen events cannot be dealt with
  - If resources are allocated statically, significant waste occurs
- **Another work assumes that application demand can be predicted through stochastical multiplexing and providers can guarantee service quality**
  - But, unforeseen events cannot be dealt with
  - This approach requires knowledge about demand profiles of applications or historical data about the execution of the application
    - But, what if a new application, of which the profile is not known, has to be executed? The calculation of an optimal resource allocation is not possible anymore. It causes large waste of resources

GridEcon's Resource Model: Unpredictability / Uncertainty

- **GridEcon builds a solution on dynamically priced resources**
  - It **relies on real-time feedback** from actual application performance to adjust resource requirements
    - It requires **less statistical information** about application
    - It needs **resource market responding in small time scales**
    - It takes care of stochastic fluctuations of application load
    - It corresponds better to Internet paradigm: adaptation to resource availability using feedback (e.g., TCP)
  - It **accommodate application types** for which an effective **prediction of requirements** can be performed

GridEcon’s Resource Model



GridEcon's Resource-Model: Characteristics

- As an underlying technology, we assume market places that offer hardware resources at dynamic prices (even under a utility computing model)
- The Grid units sold to end-users may differ since different types of application may fit best to different types of virtual resource units
- The user has the final decision on the overall application quality by considering the trade-off between resources assigned and the charge to be paid
- Sophisticated market services provide guarantees on top of the basic markets

The Future

- The **kind of feedback** info that the user should get will be examined. What is the user actually controlling? Overall performance? Particular QoS parameters?

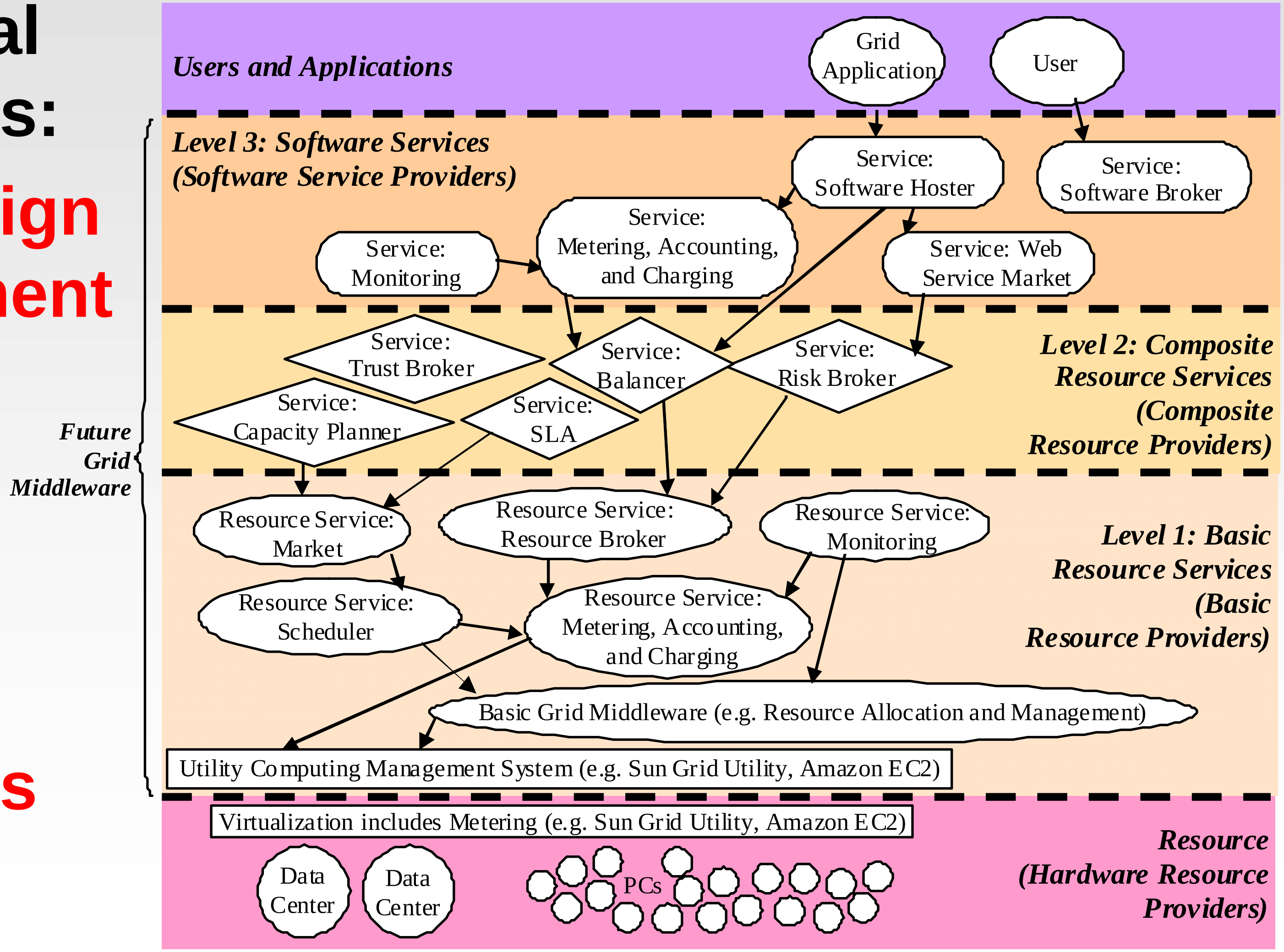
- We investigate different **adaptation models**
  - Simplest case: user is responsible for taking action
  - More elaborate: intermediaries (brokers) hide complexity, they use some predetermined user profile for responding in small time scales

- The design of market mechanism to **minimize adaptation cost** (the cost of reallocating resources at real time) has to consider the requirements at lower layer

- We look into the economics of the **interaction between software and hardware** resources
  - E.g. Web servers and its demand for hardware

The Future

- Further develop GridEcon's reference architecture of functional components:
- We will **design and implement** only a few of our ideas of **economic-aware components**



The Future

- **The implementation will be based on RIO and GridSam (open source middleware)**
  - **Test new concepts of adaptive performance** in small time scales
    - The dynamic adaptation of resources can deal with the unpredictability of sum of loads of many services
  - **Validate the type of feedback** that is useful and the ways to use it
  - **Show innovative ways to market-manage lower layers**
    - Virtual resource unit types (gold-, silver-, bronze-quality virtual machines) will be defined so that they can easily be implemented

Expected Gains

- **Knowledge on how markets for higher, software service layers and lower (hardware resource) layers may depend on each other**
  - In certain application environments (e.g. Web), the **higher layer** may be specifically designed **to make use** of specific features of the lower layer
  - The higher layer concepts in our functional architecture **might also dictate** some requirements on the lower layers
    - **Time scale of resource re-allocation**
    - **Feedback about performance of application**
- **A complete reference functional architecture for economic-aware Grid components and its interdependencies**

Expected Gains

- **Alternative methods for resource allocation suited for Web applications and software as a service**
  - Think of **SaaS as a package of software and hardware QoS**, where QoS is elastic (Internet-like)
    - Adaptation to variable resource availability is part of Web application's semantics (i.e. it can live in such an environment by construction)
- **The broader economic understanding of Grid technology implications**
- **A comprehensive taxonomy of Grid business models**

Thank you