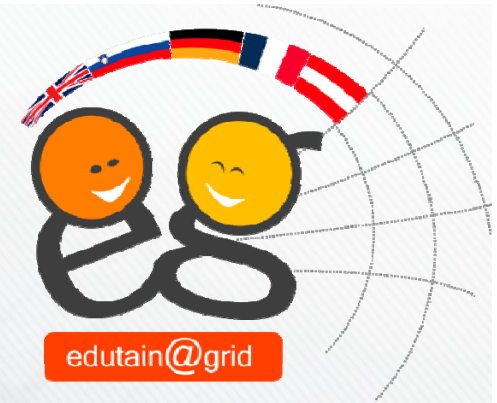


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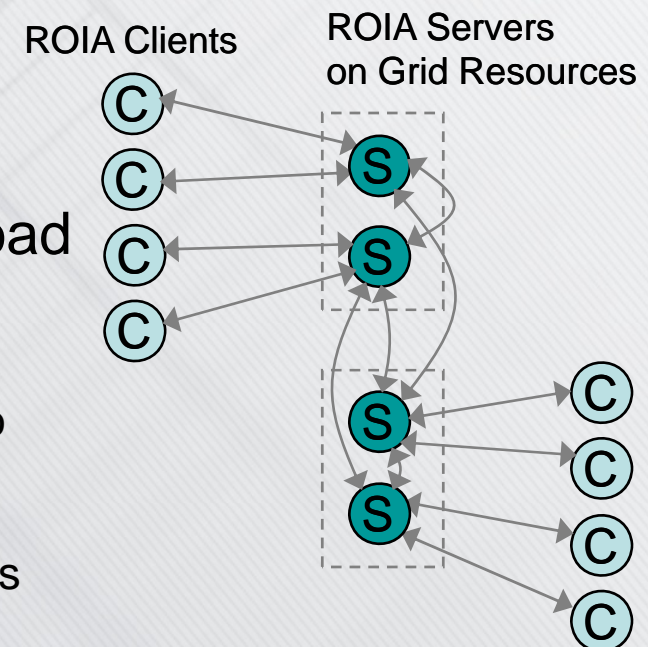
Grid Support for Real-Time Online Interactive Applications

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Institute of Computer Science
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- Real-Time Online Interactive Applications
 - **Online games**, e-learning, multimedia applications, ...
- ROIA are a new class of Grid applications
 - Multiple users share the same application instance
 - Impact the dynamics of the application as a community
- Ad-hoc user connections, often by using anonymous or different pseudonyms
- On-demand provisioning of computational servers to ROIA sessions based on user load
 - Avoid over-provisioning
- Real-time QoS requirements
 - State update rate per second from game servers to game players
 - 60 Hz in fast-paced FPS action games
 - Latency and bandwidth between clients and servers
- Competition-oriented Virtual Organisations
 - Cheating prevention



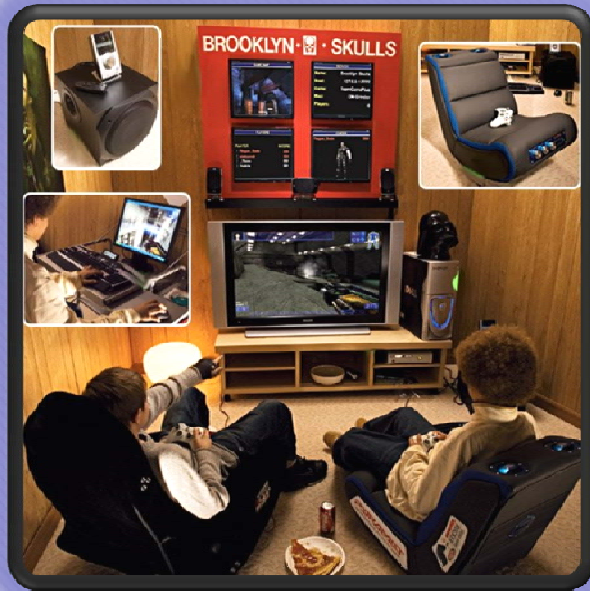


- Use Grid technology for Massively Multiplayer Online Games
- Real-Time Online Interactive Applications (ROIA)
 - Online games
 - E-learning applications
- Total funding: 3M €
- Duration: 36 months
- Progress: month 19
- Partners:
 - University of Innsbruck (Austria)
 - University of Münster (Germany)
 - University of Linz (Austria)
 - Darkworks – game developer (France)
 - AMIS – telecommunication company (Slovenia)
 - IT Innovation – research centre (U.K.)
 - BMT Cordah – business/e-learning software developer (U.K)

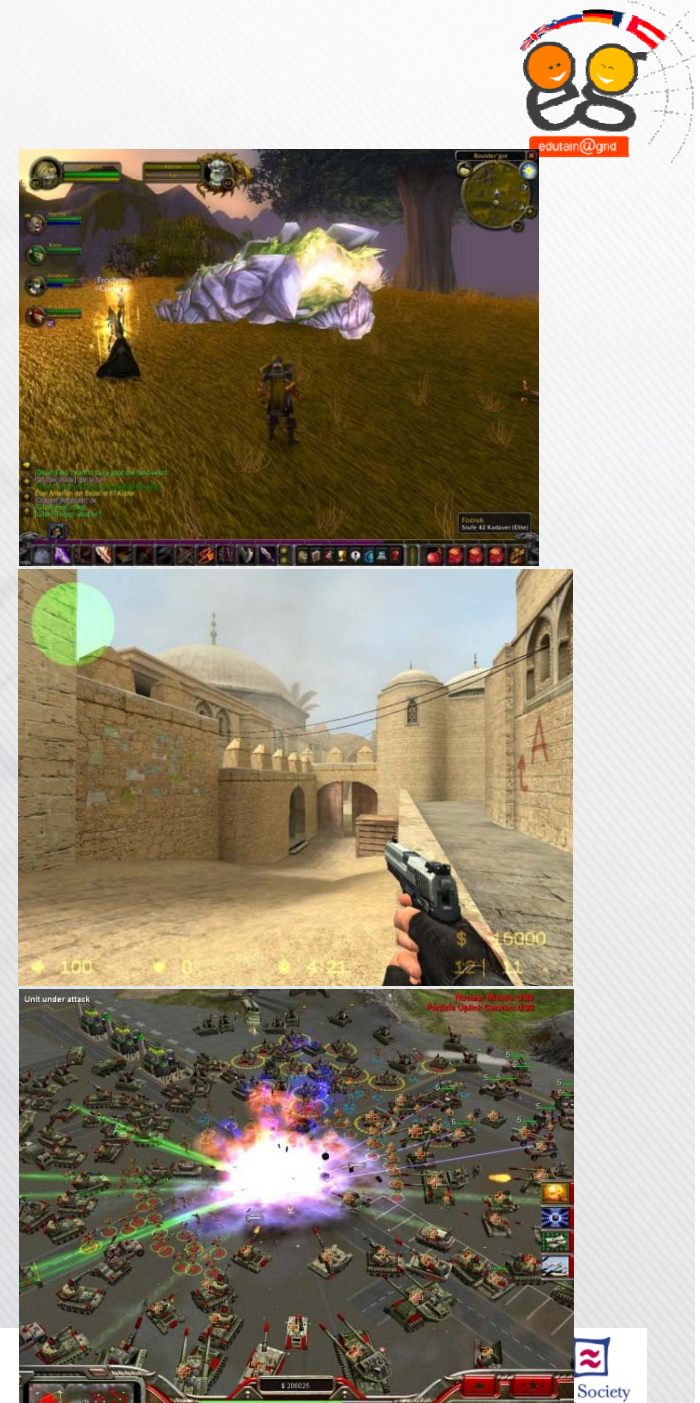


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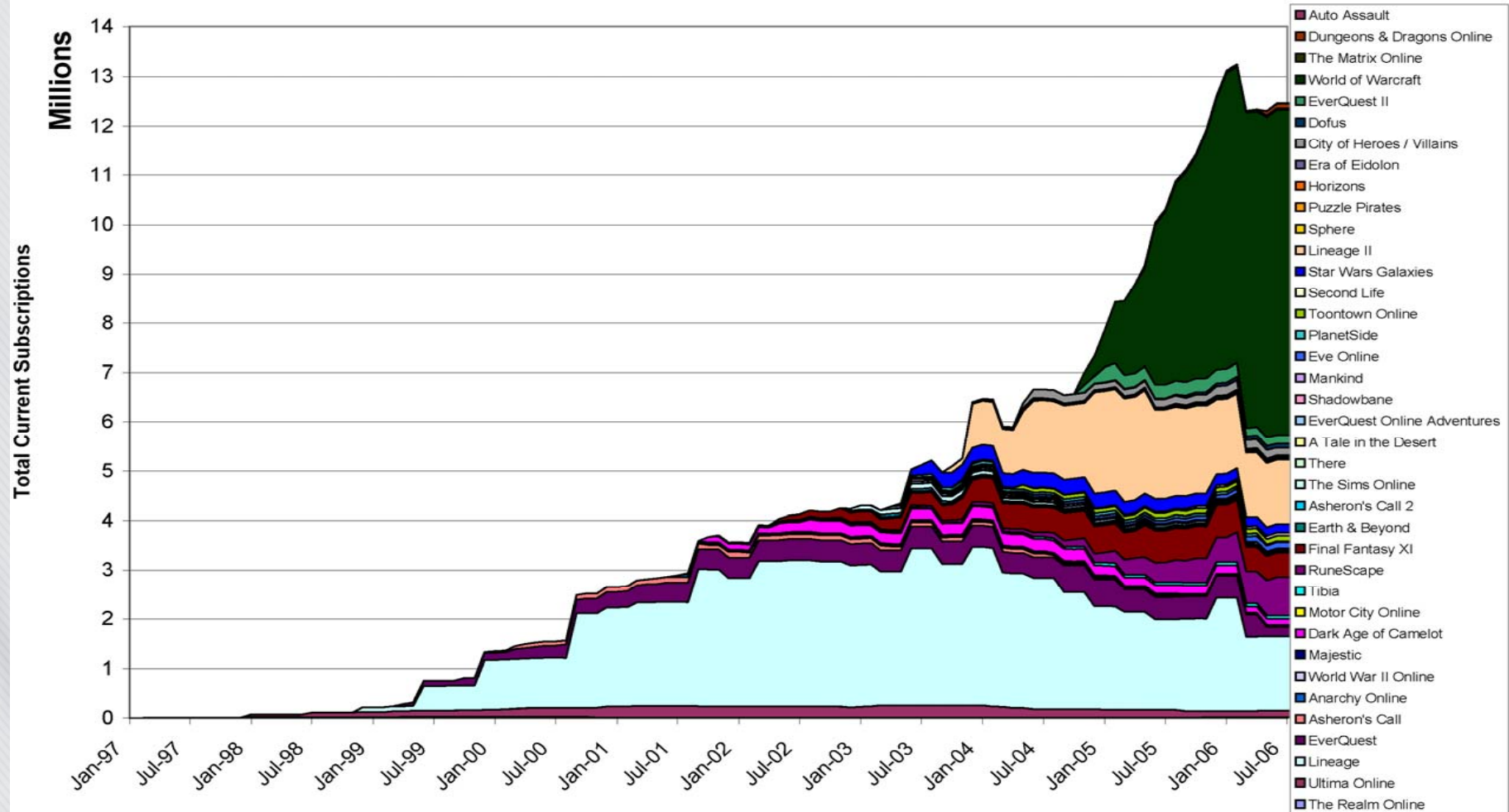
Massively Multiplayer Online Games



- Massively Multiplayer Online Role Playing Games (MMORPG)
 - Adventure games
 - Lineage I & II, Runescape, World of Warcraft
 - Thousands of players sharing one persistent game session in a huge game world
- First Person Shooter (FPS)
 - Action games
 - Counter Strike Source, Battlefield 2142
 - Maximum 64 players in one ephemeral session (minutes or hours)
 - No MMOG support yet
- Real-Time Strategy (RTS)
 - Economic and battle strategy games
 - Command & Conquer, Starcraft

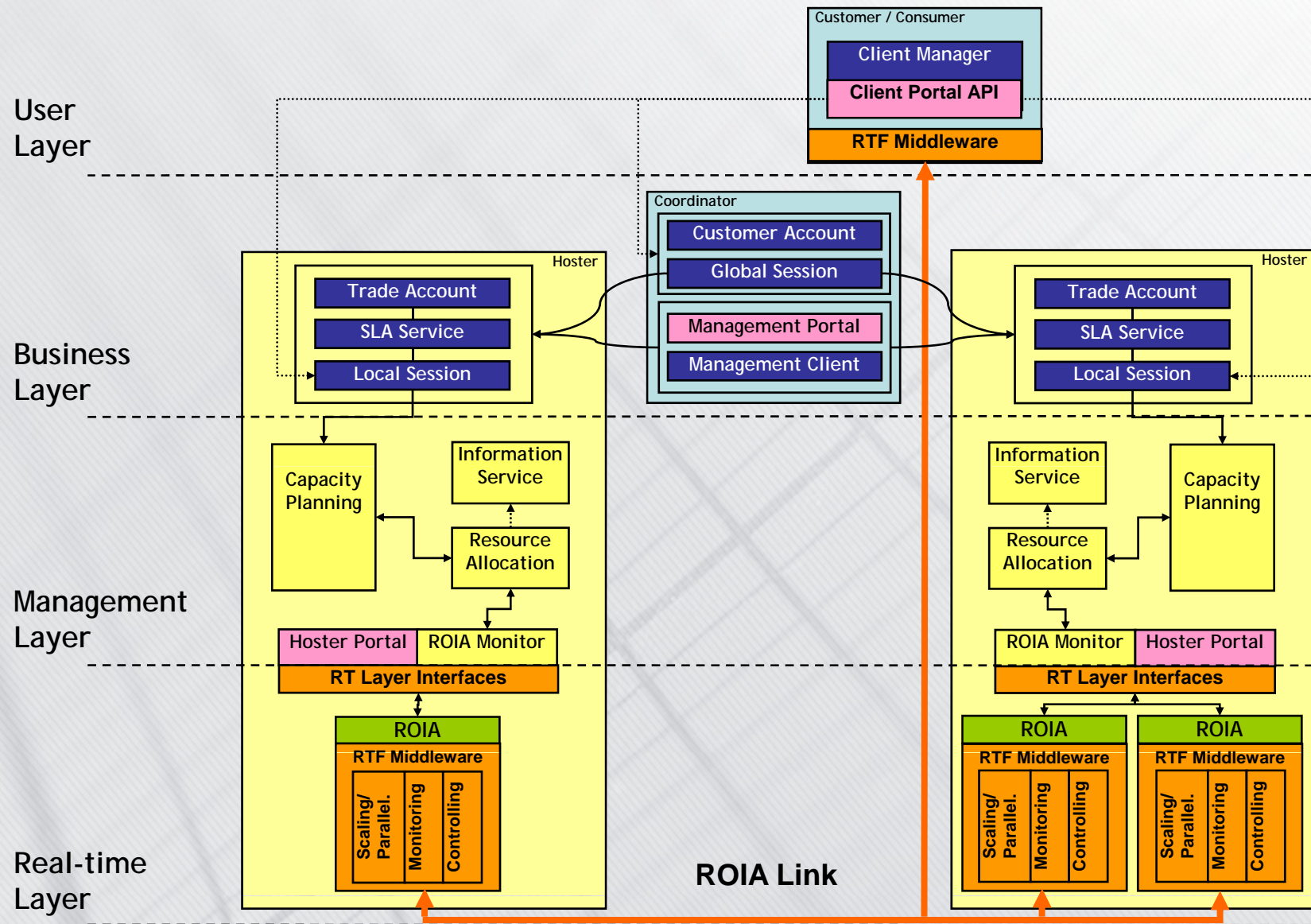


Total MMOG Active Subscriptions - Absolute Contribution



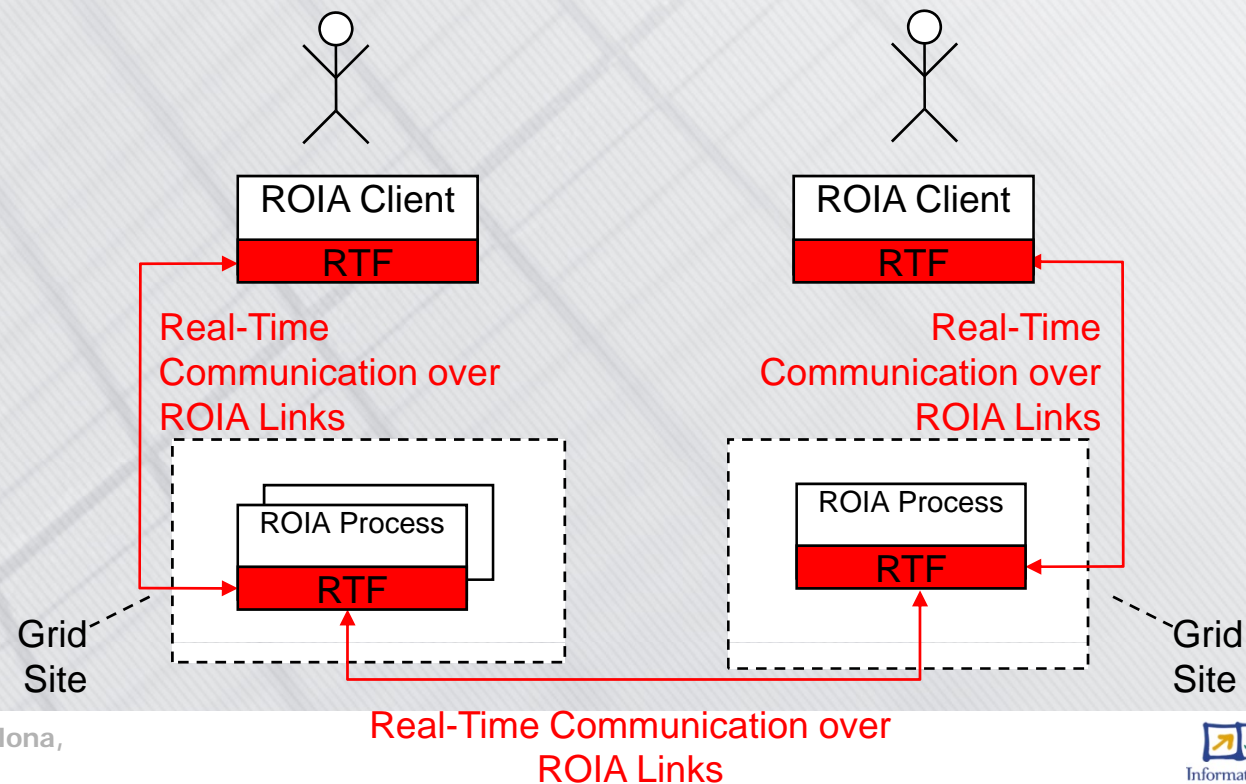
- Over the last 10 years the number of players has increased 20 fold
- 60 million people by 2011

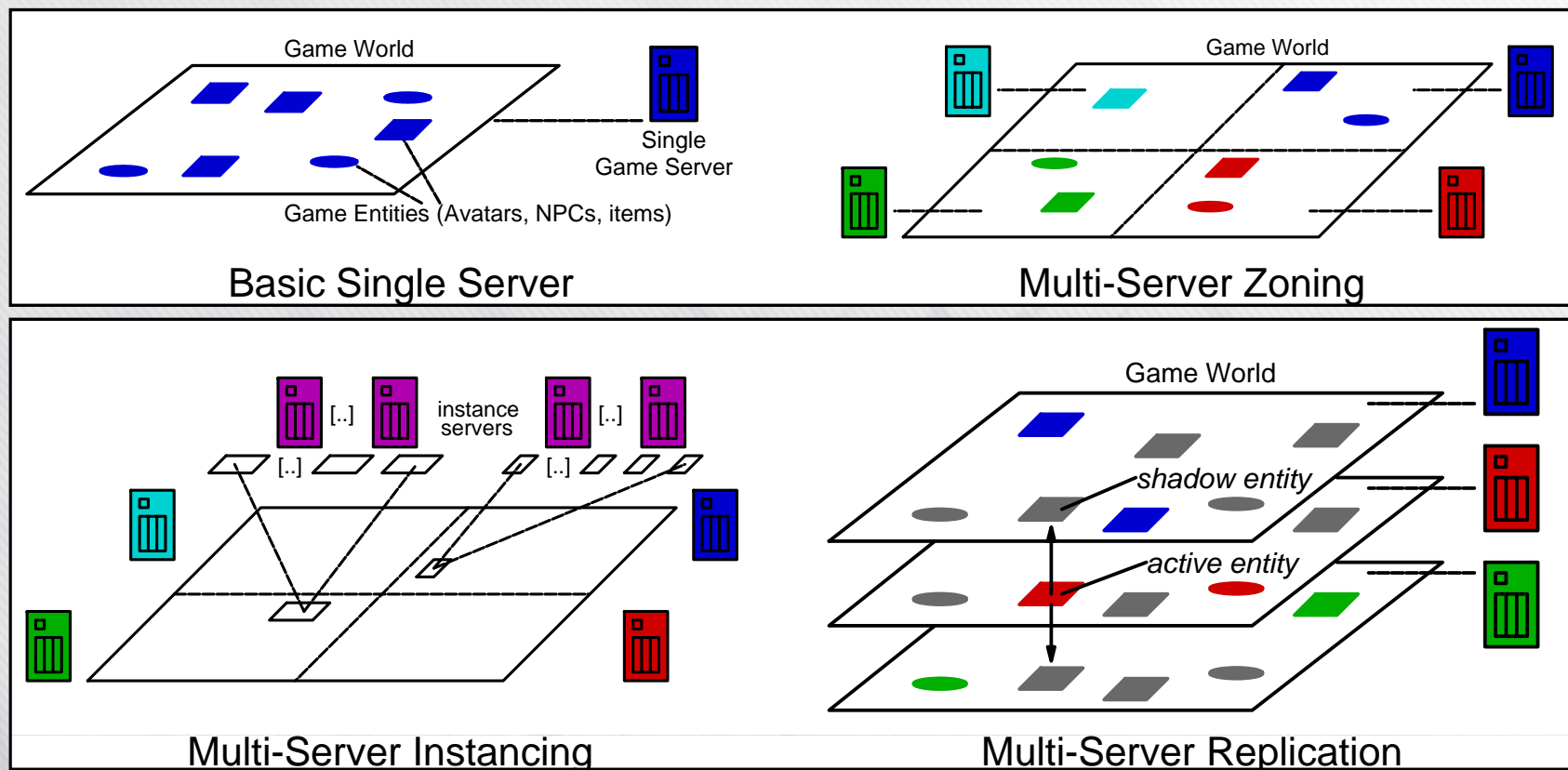


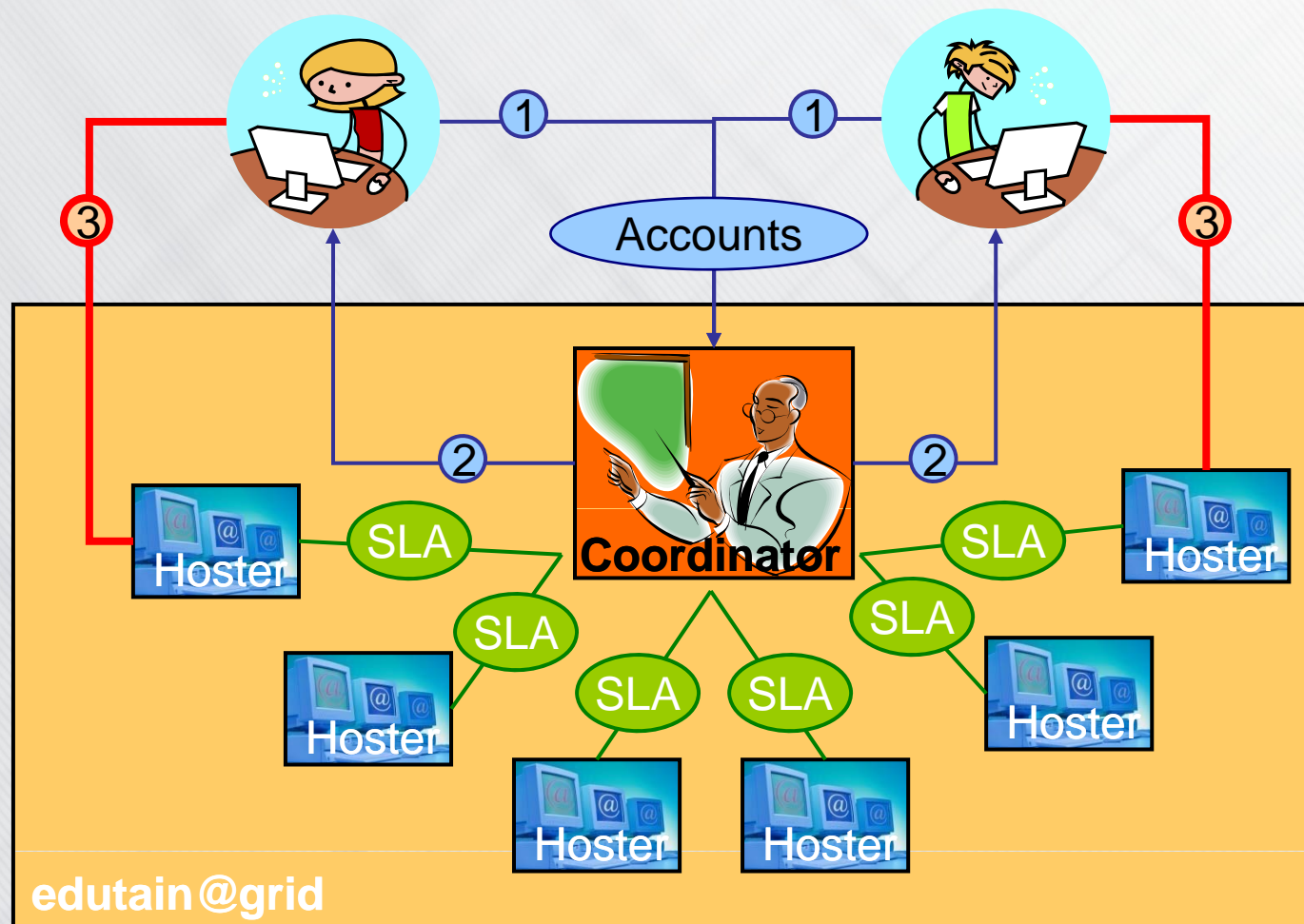




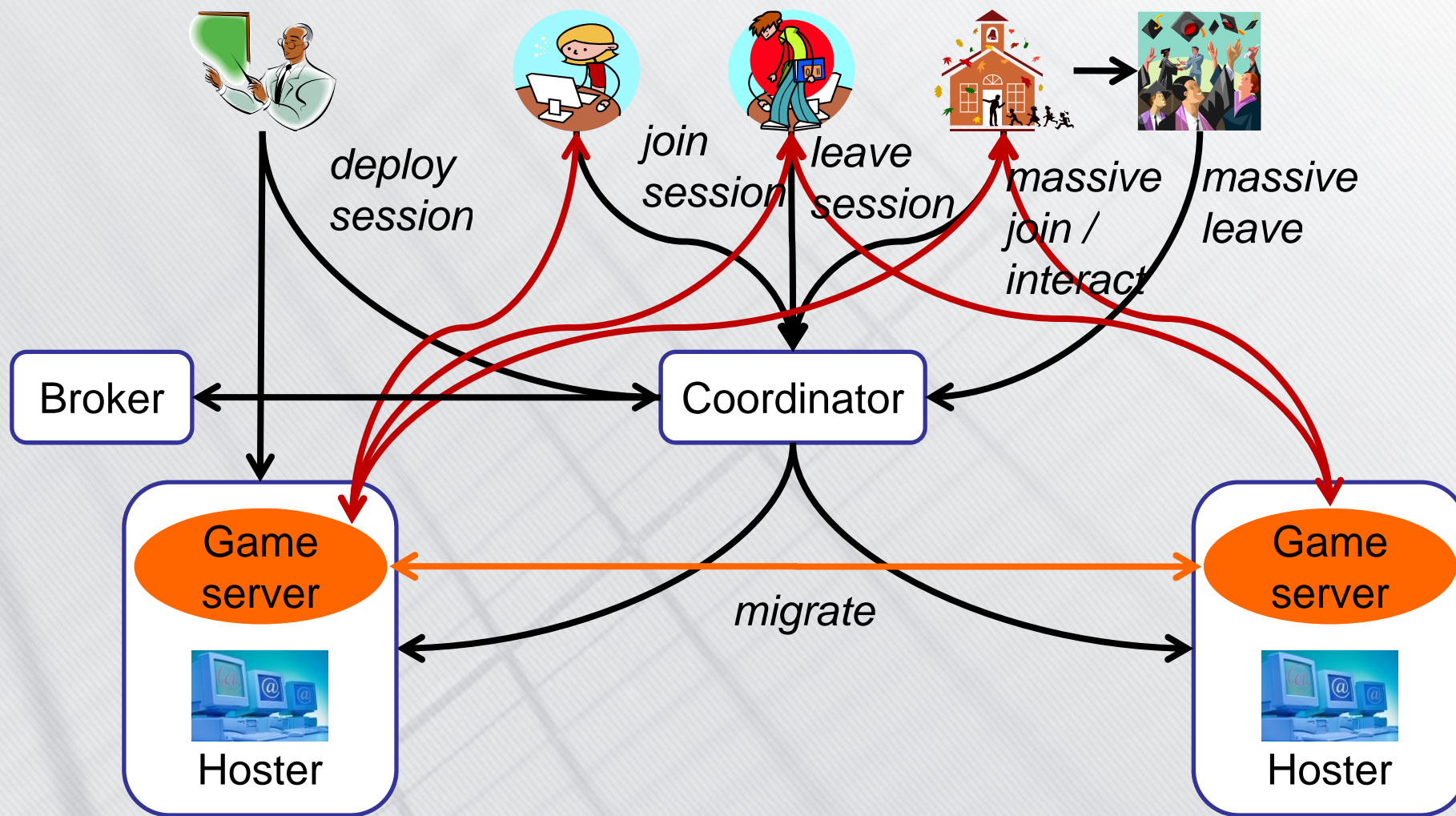
- Distribute the game server load on multiple processors
- RTF library developed at the University of Münster
 - Game server parallelisation strategies
 - Standard portable API for game development
 - Optimised real-time communication protocols





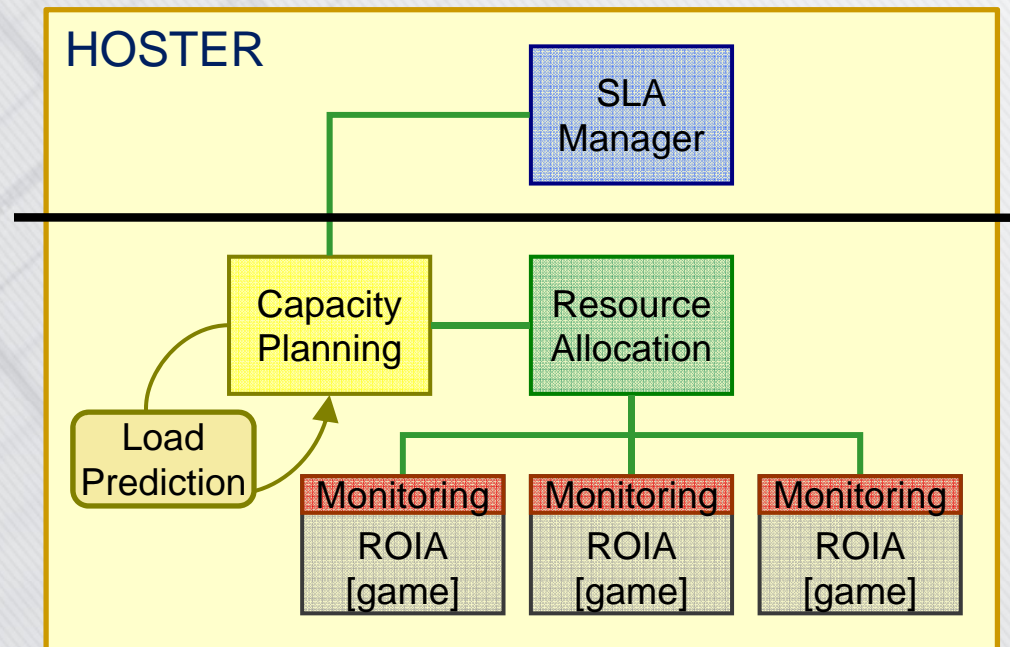


- SLA – number of client connections for a certain period





- Capacity planning
 - Analytical models to project future game server load
 - Maps business SLAs into local resource allocation units or QoS parameters
 - Plans and requests “optimal” local resource allocation
 - Decides new ROIA distributions
 - Signals to the SLA manager potential QoS violations
- Load prediction
 - Predicting the future entity distribution
- Monitoring service
- Resource allocation
 - Provides Host resources to run the ROIA servers
 - Requests new ROIA distributions to RTF
 - Provides connection details about ROIA local session and client links





- **load = f (entityCount, entityInteraction)**
- Interactions occur within area of interest of entities
- State and interactions of all entities within the area must be computed every 60 Hz
 - Hard QoS requirement
- Prediction of game world entity position

Memory Load Model

$$L_{MEM} = \frac{M}{M_{HOST}} = \frac{N \cdot m_{cs} + BE \cdot m_{es} + m_{game} + m_{world}}{M_{HOST}}$$

CPU Load Model

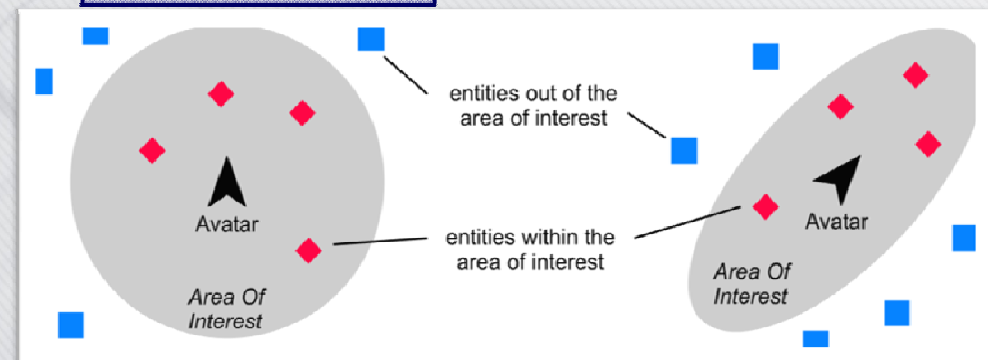
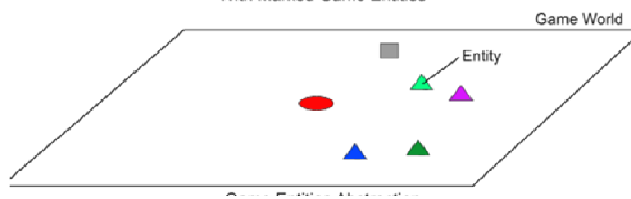
$$L_{CPU} = \frac{T_C}{T_{SAT}} = \frac{p_{ci} \cdot IC^2 + p_{ei} \cdot (AE + BE) \cdot IC + N + BE}{S}$$

Network Load Model

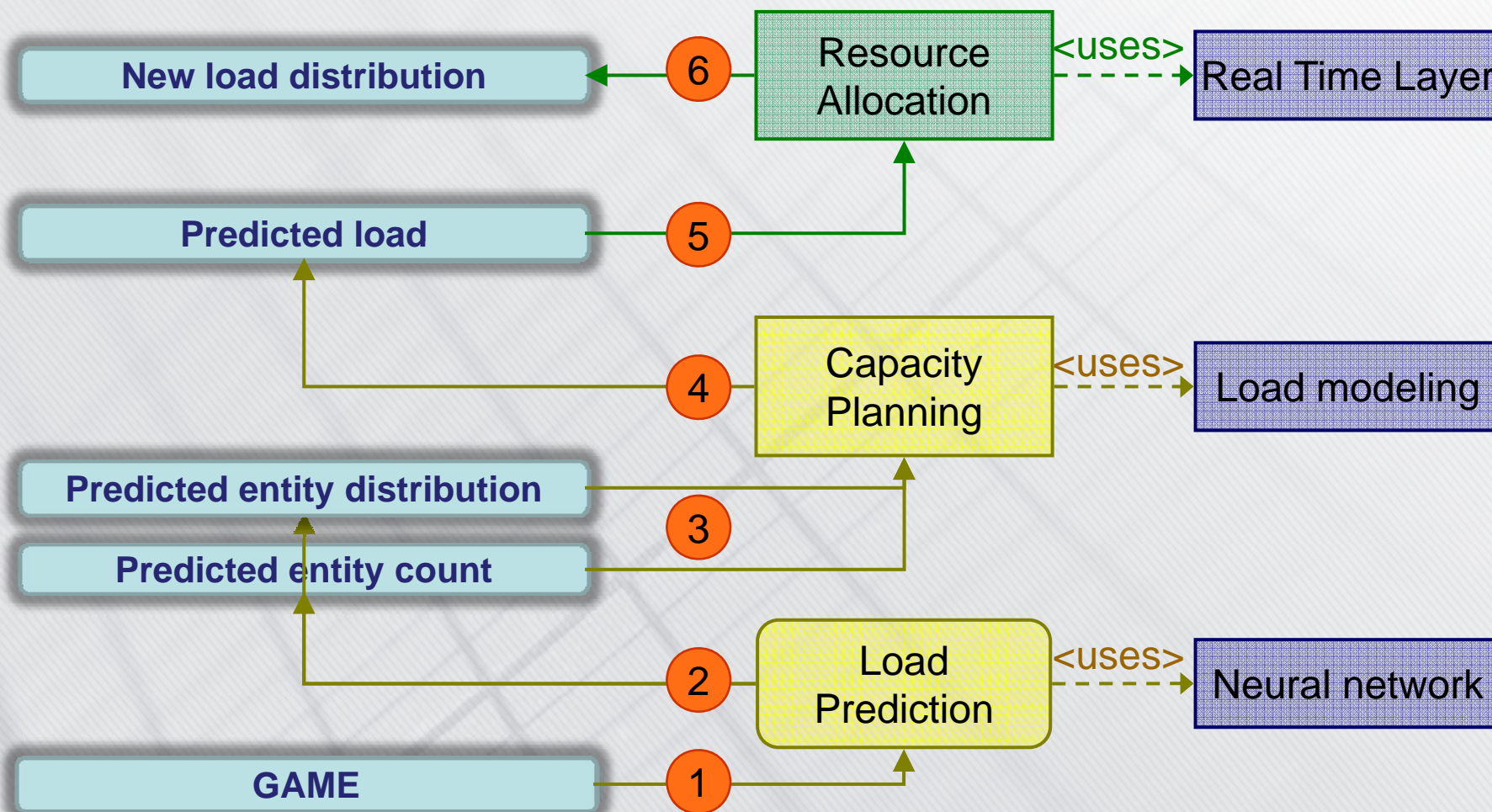
$$L_{NET} = \max \left(\frac{D_{out}}{B_{out}}, \frac{D_{in}}{B_{in}} \right)$$

MAX

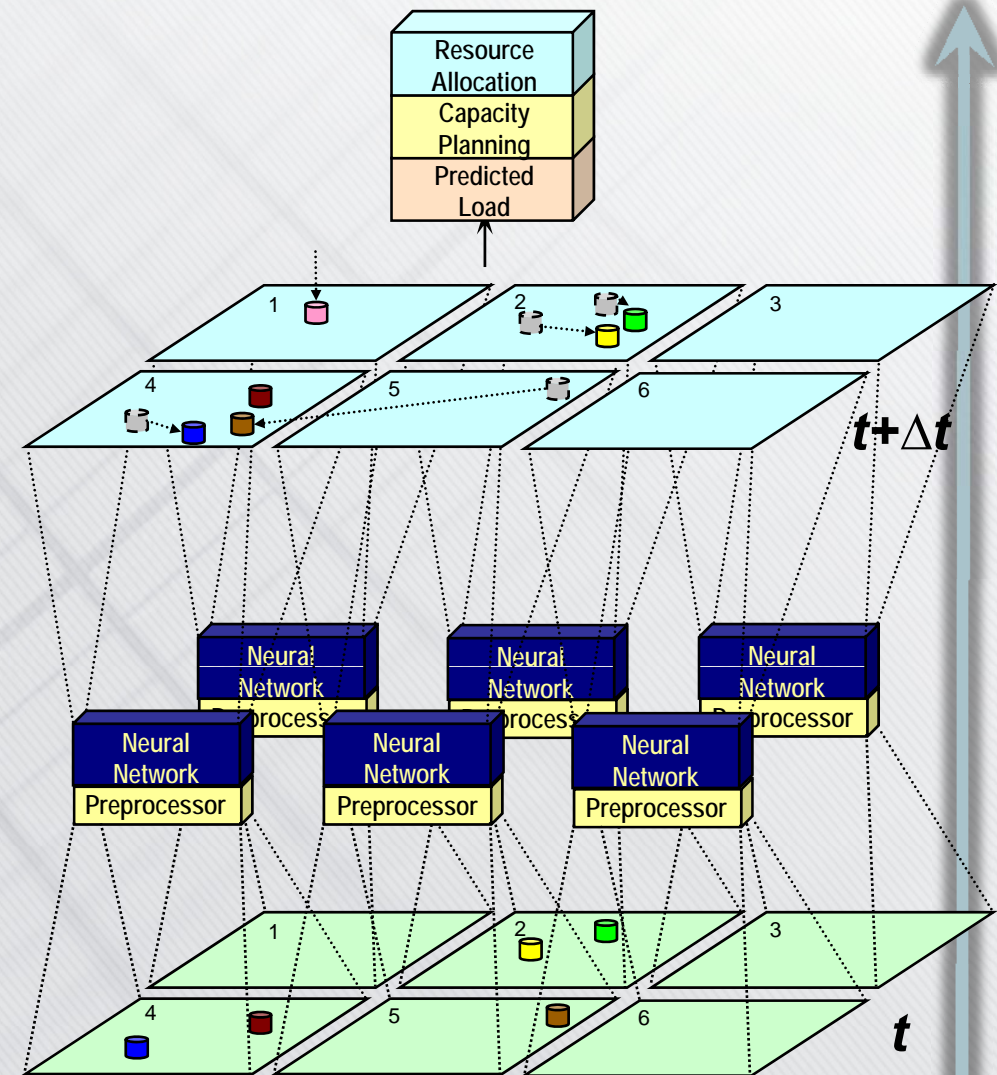
LOAD

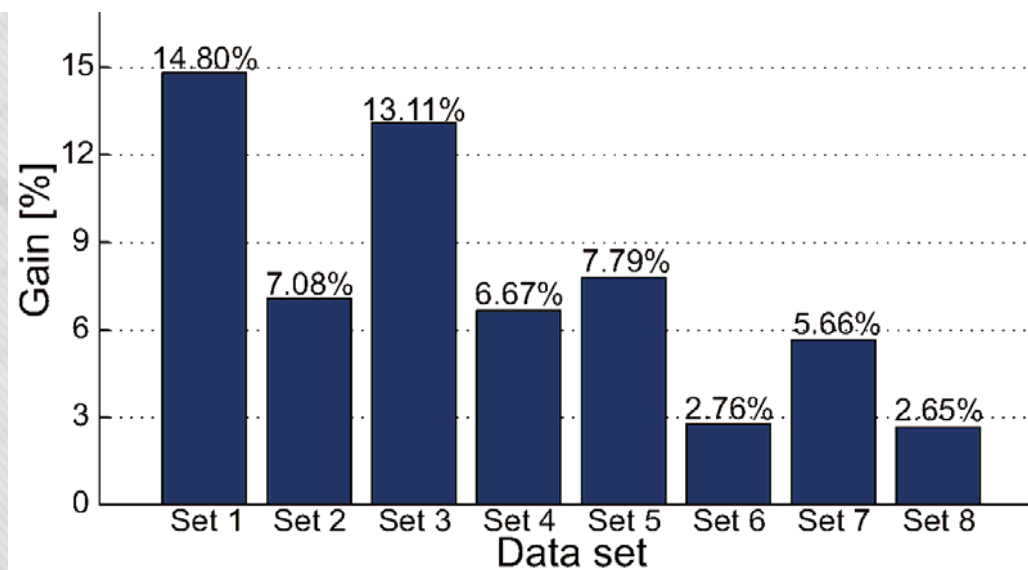
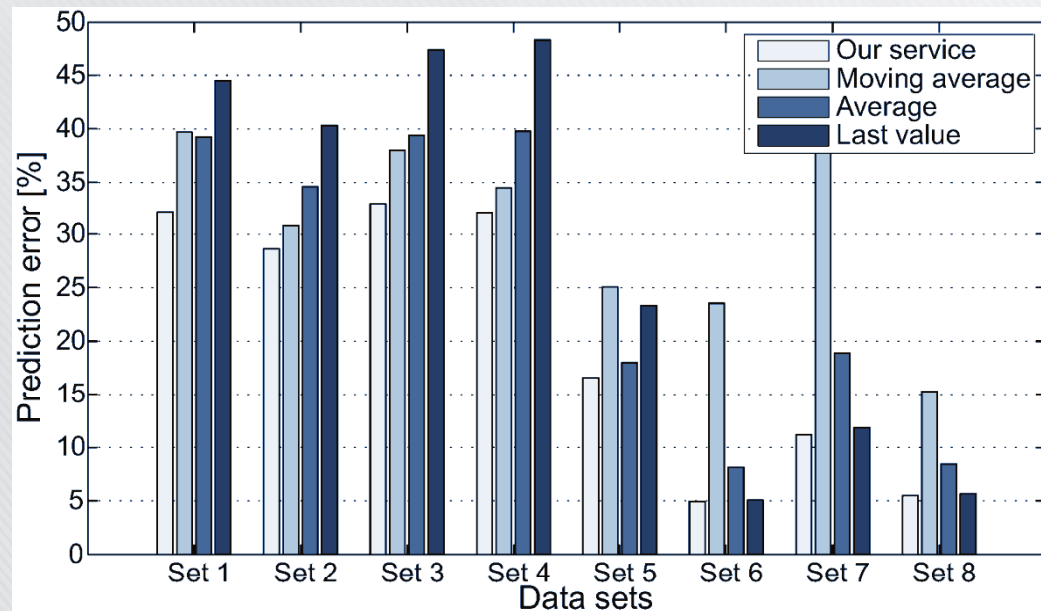
World Of Warcraft Screenshot
With Marked Game Entities

Game QoS Management Strategy



- Predict the future entity layout in the game world
 - Partition the game world into subareas
 - Predict the number of entities in each subarea
 - Time series-based method based on historical entity distribution
- Neural network-based
 - Adapt to a wide range of time series
 - Better prediction results than simple methods
 - Faster than statistical analysis







- Grid support for Real-Time Online Interactive Applications
- Online games are our main focus
- Layered Grid architecture
- Real-time framework for portable game session parallelization and load distribution
- Grid management layer for QoS-enabled resource provisioning
 - Monitoring a broad variety of real-time metrics
 - Load prediction of future entity distribution
 - Analytical load modeling for projecting game load from future entity distribution
 - On-demand Grid resource provisioning avoids the current over-allocation practice
- Future work
 - Integrated use of RTF, monitoring, load prediction, and resource allocation service for seamless scaling and load balancing of MMOG sessions

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