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MASSIVELY MULTIPLAYER ONLINE GAMING ON LARGE SCALE SYSTEMS

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Introduction

- Alpen-Adria-Universität Klagenfurt

- University professor for Distributed Systems

- Institute of Information Technology
  - Over 20 scientific, technical and administrative members
  - 2 full professors, 3 associate professors
  - **http://itec.aau.at/**

Klagenfurt am Wörthersee

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2016-2020 GLOBAL GAMES MARKET
FORECAST PER SEGMENT TOWARD 2020

Entertainment and Media in Netherlands

E&M consumer spending by sector (€ millions)
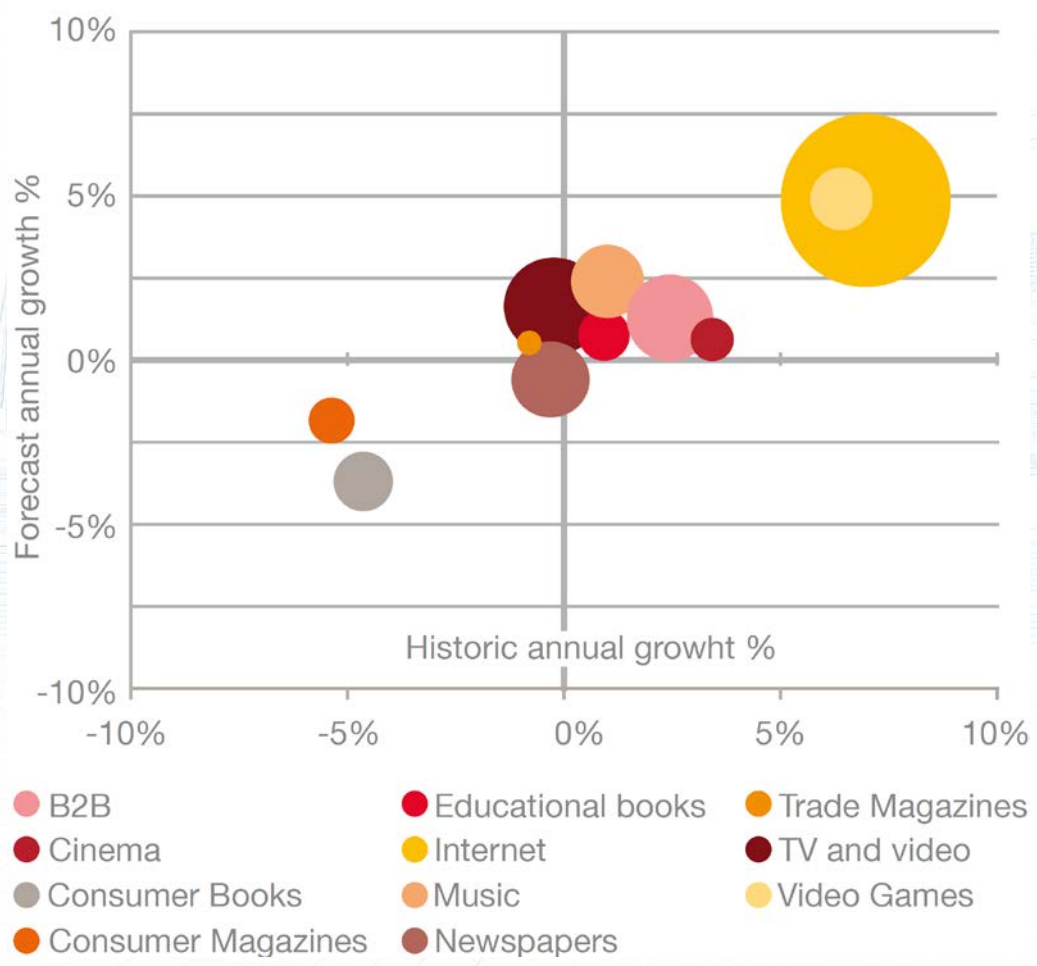
THE DUTCH GAMES MARKET

KEY 2016 FACTS

TOTAL GAME REVENUES
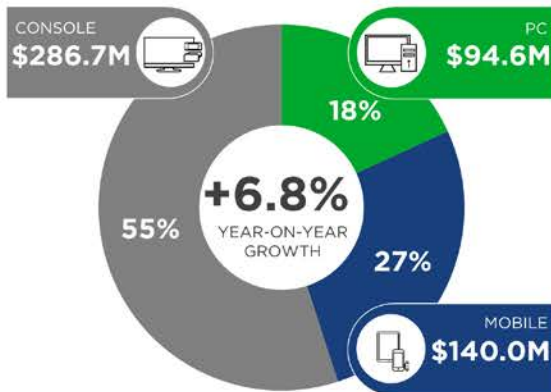$521.3M

#19 MARKET IN THE WORLD

REVENUES PER SEGMENT
SHARE AND IN $M FOR 2016

CONSOLE $286.7M
PC $94.6M
18%
+6.8% YEAR-ON-YEAR GROWTH
55%
27%
MOBILE $140.0M

16.1 MILLION — ONLINE POPULATION
43% OF THE ONLINE POPULATION PLAY GAMES

6.9 MILLION — ALL GAMERS
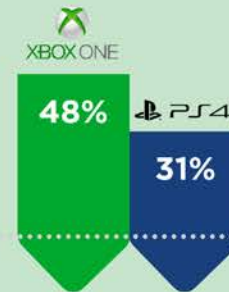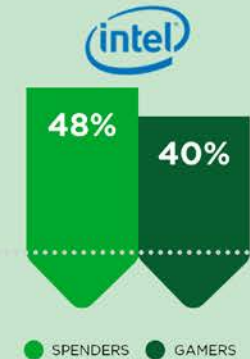51% OF ALL GAMERS SPEND MONEY

3.5 MILLION — PAYING GAMERS
$148 WILL BE SPENT PER PAYING GAMER ON AVERAGE IN 2016

newzoo GAMES

SHARE PLAYS RACE GAMES ON CONSOLE
XBOX ONE VS. PLAYSTATION 4 OWNERS
XBOX ONE 48%
PS4 31%

BRAND ATTITUDE
POSITIVE BRAND ATTITUDE INTEL: GAMERS VS. SPENDERS
intel
48%
40%

● SPENDERS ● GAMERS

GLOBAL VIEW
GLOBAL GAMES MARKET REPORT (QUARTERLY) $6,900/YR

COUNTRY INSIGHTS
CONSUMER GAMER INSIGHTS (200 VARIABLES) $5,000/YR

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MMOG Genres

- Massively Multiplayer Online Role Playing Games (MMORPG)
  - Adventure games
  - World of Warcraft, Eve Online, Second Life, RunScape, ...
  - Thousands of players sharing one game session in a huge persistent game world

- First Person Shooter (FPS)
  - Action games
  - Counter Strike, Battlefield, Doom, Quake, ...
  - Few hundreds players in one ephemeral session

- Real-Time Strategy (RTS)
  - Economic and battle strategy games
  - Starcraft, Empire: Total War, Age of Empires, Dune II, ...

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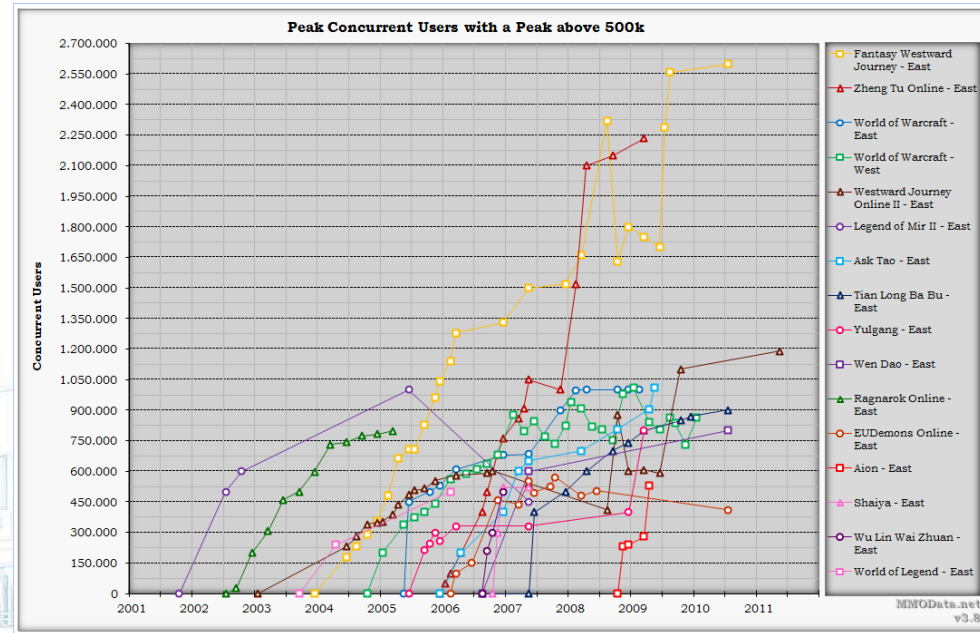www.aau.at

MMOG Computational Model
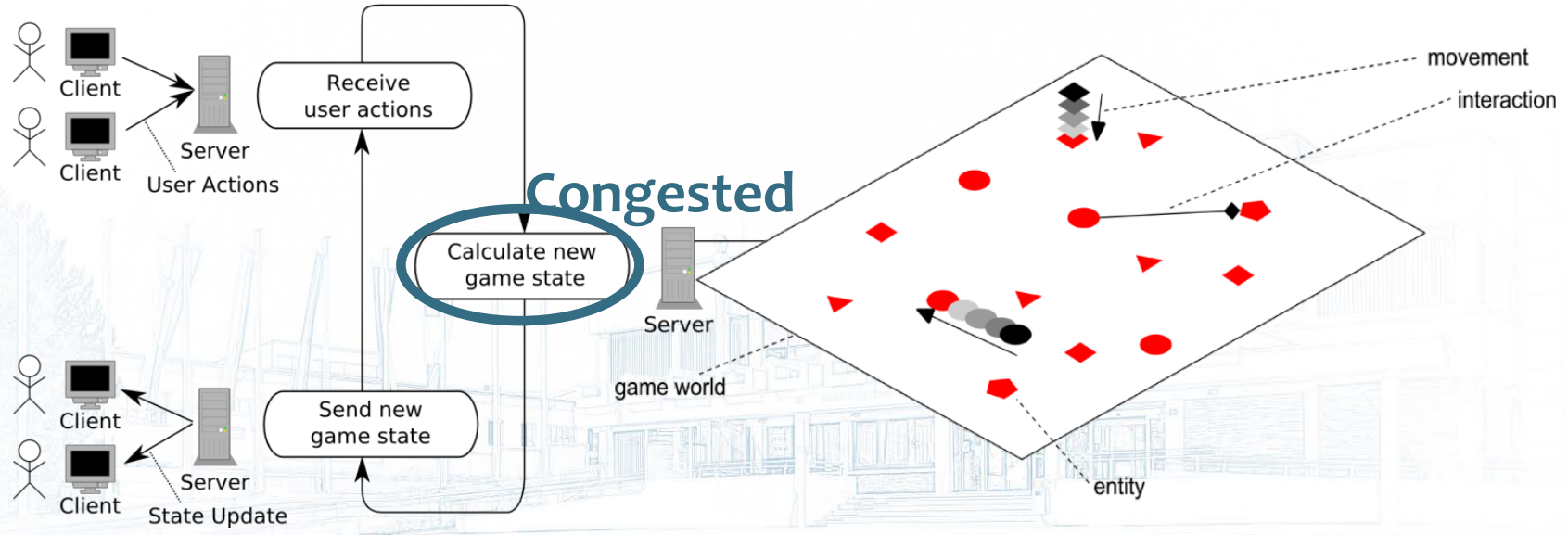
Congested

- **Real-time server loop**
  - Up to 100 Hz depending on game type

- **Number** and **density of players** in a game session generates **load** that congest servers

MMOG Load
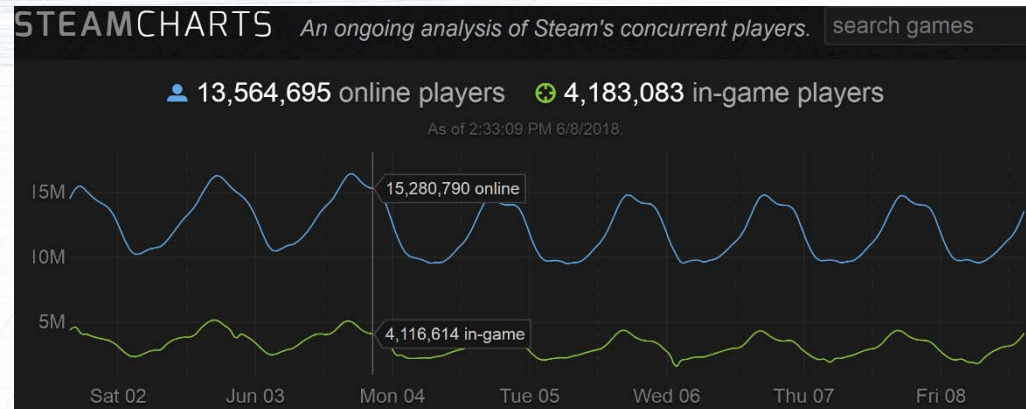
- ## Long-term demand
  - http://mmodata.blogspot.co.at/
  - MMOG providers operate large data centres

- ## Short-term demand
  - http://steamcharts.com/
  - Resource overprovisioning

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MMOG Software Stack

Service Level Agreements

QoS fault tolerance

Resource provisioning

Load modelling

Parallelisation

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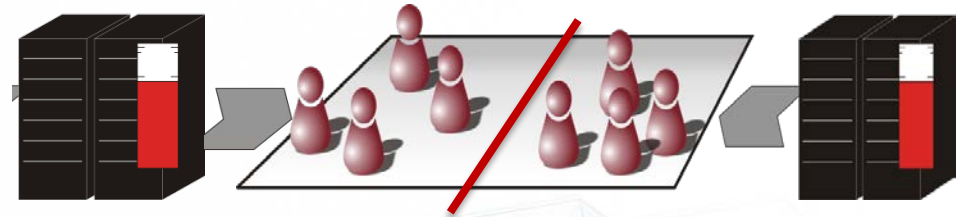Informationstechnologie
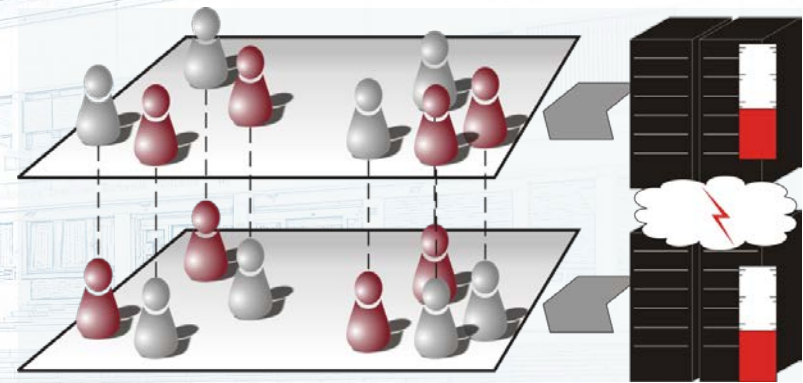
Game Server Parallelisation
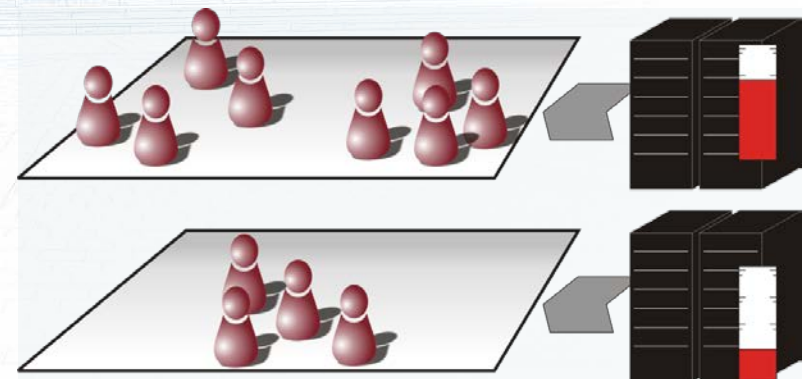
- **Zoning**
  - Spatial partitioning
  - Geographical sub-zones

- **Replication**
  - Entity distribution
  - Synchronised states

- **Instancing**
  - Multiple instances with independent states

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FPS Game Demonstrator

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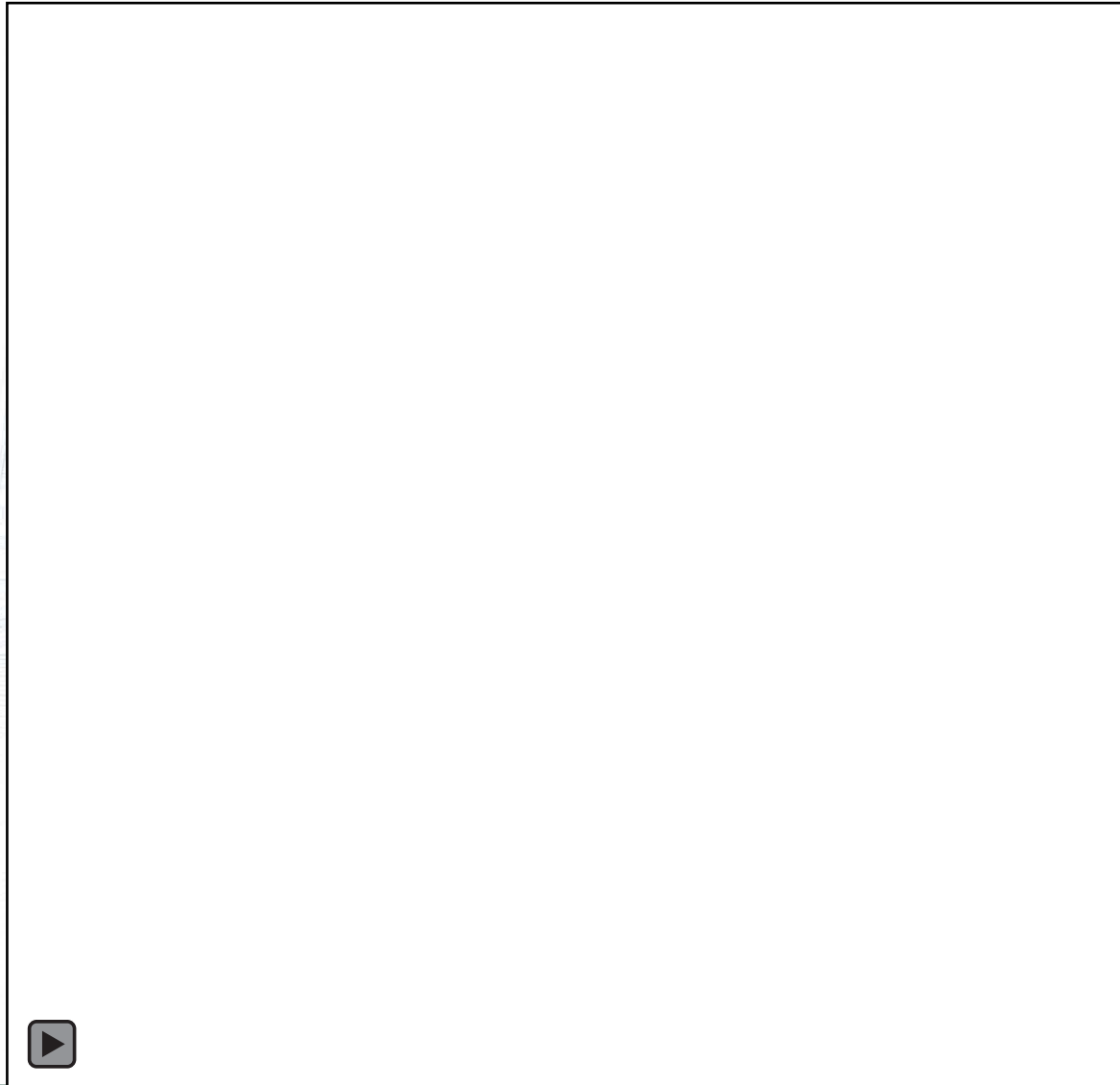
MMOG Interaction-based Scaling

- several bot injection waves

Zone 0   Zone 1

R1   R1

R2
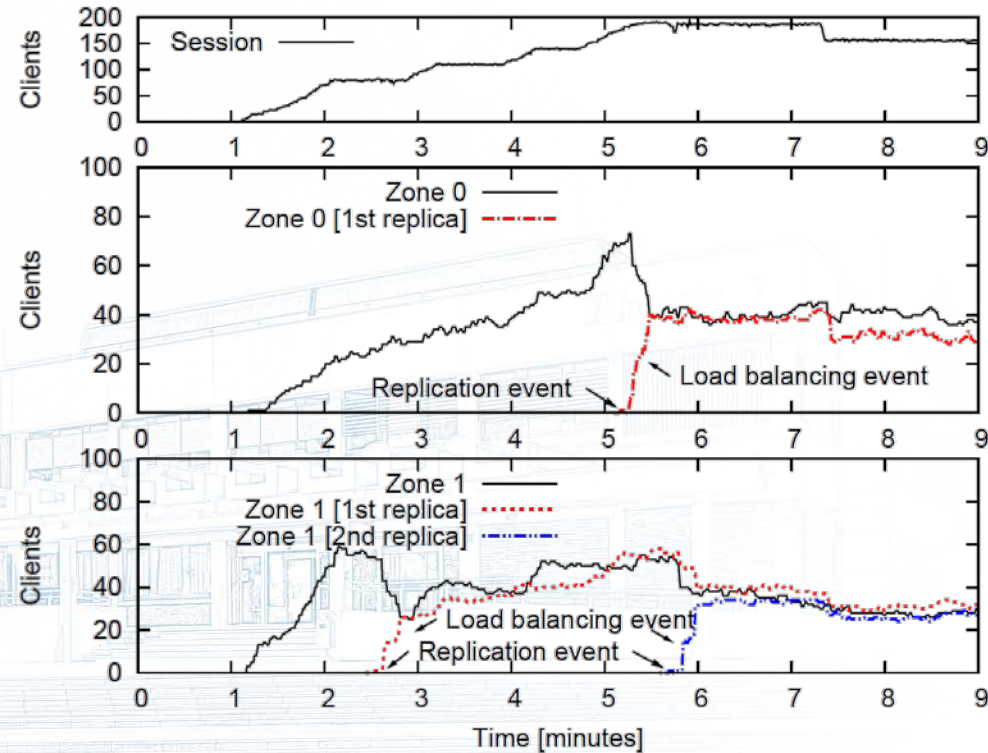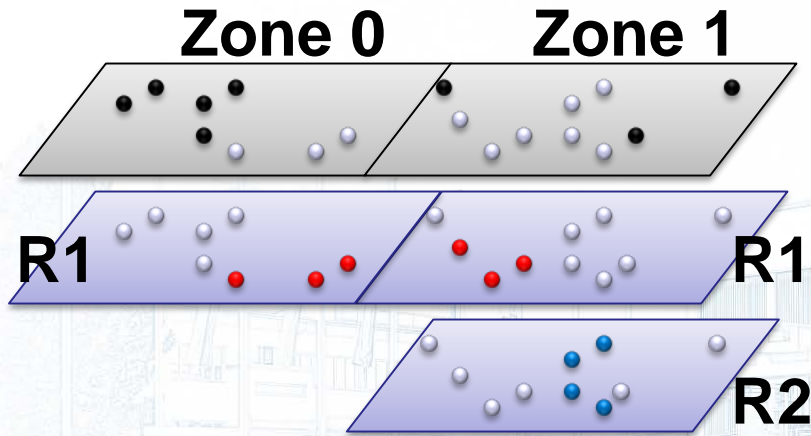
Metric	Player density and interaction-based	Player threshold-based	
		40 clients/server	50 clients/server
QoS violations	0.66%	0.86%	8.69%
Resource utilisation	83.3%	100%	83.3%

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Load Modelling

- Three characteristics
  - **Entity distribution** (position)
  - In-game **player interaction** (complexity)
  - **Resource benchmarks** (Amazon EC2)

$$f(e_1, e_2) = \begin{cases} e_1 + e_2 & O(n) \\ e_1 \cdot \log n & O(n \cdot \log n) \\ e_1 \cdot e_2 & O(n^2) \\ e_1^2 \cdot \log e_2 & O(n^2 \cdot \log n) \\ e_1^2 \cdot e_2 & O(n^3) \end{cases}$$
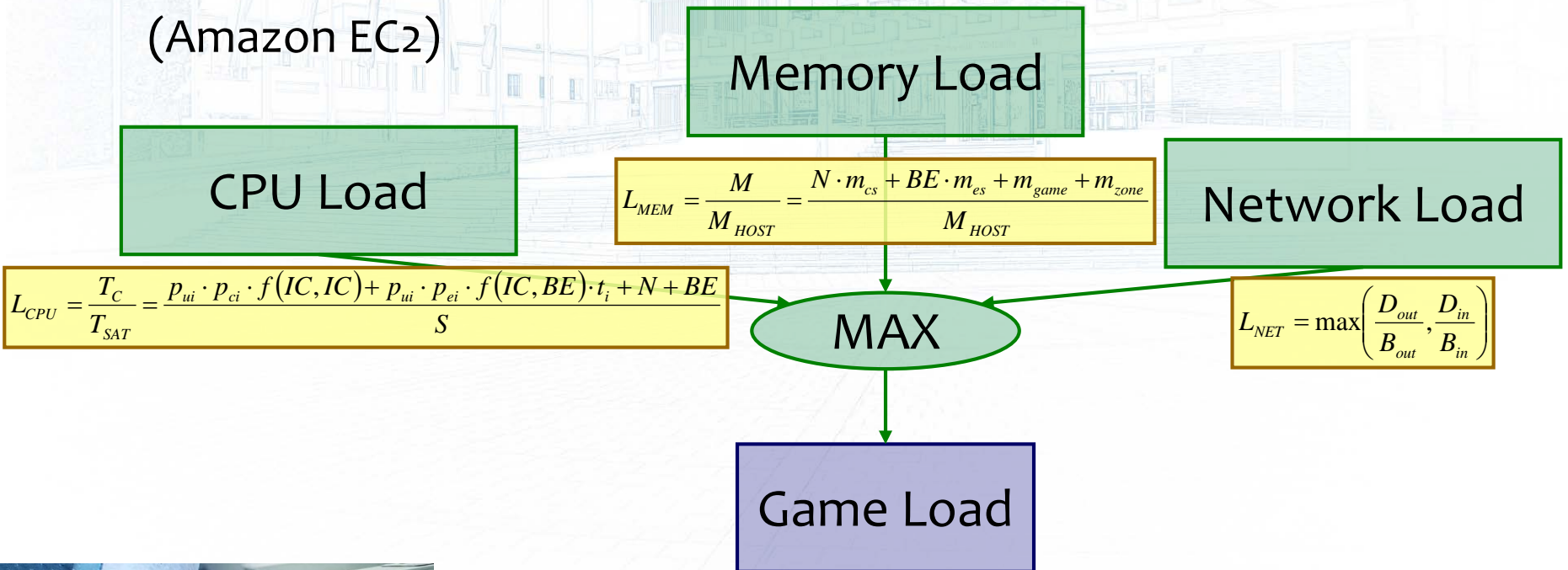
Memory Load

CPU Load

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

Network Load

$$L_{CPU} = \frac{T_C}{T_{SAT}} = \frac{p_{ui} \cdot p_{ci} \cdot f(IC, IC) + p_{ui} \cdot p_{ei} \cdot f(IC, BE) \cdot t_i + N + BE}{S}$$

MAX

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

Game Load

Entity Distribution Prediction

- Split game world into subareas

- Monitor number of entities in each subarea

- Use history to predict future entity distribution
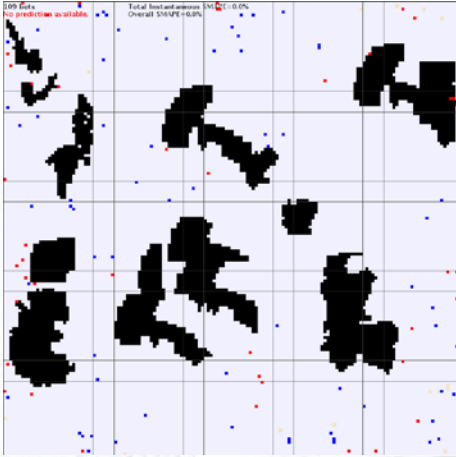
- Single ML-based method that covers multiple player behavioural models
  - Achiever, explorer, socialiser, killer, …
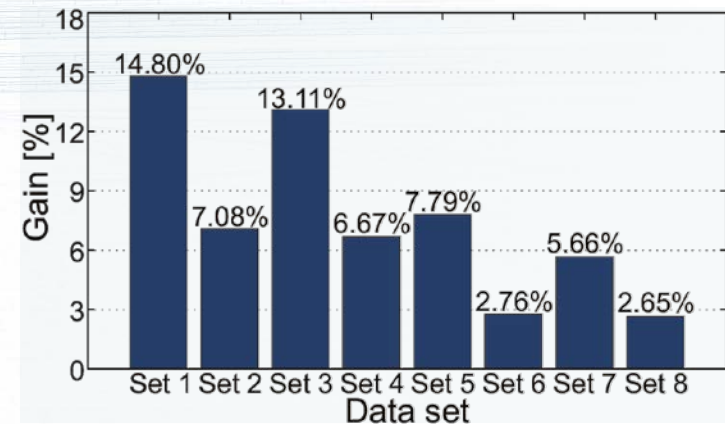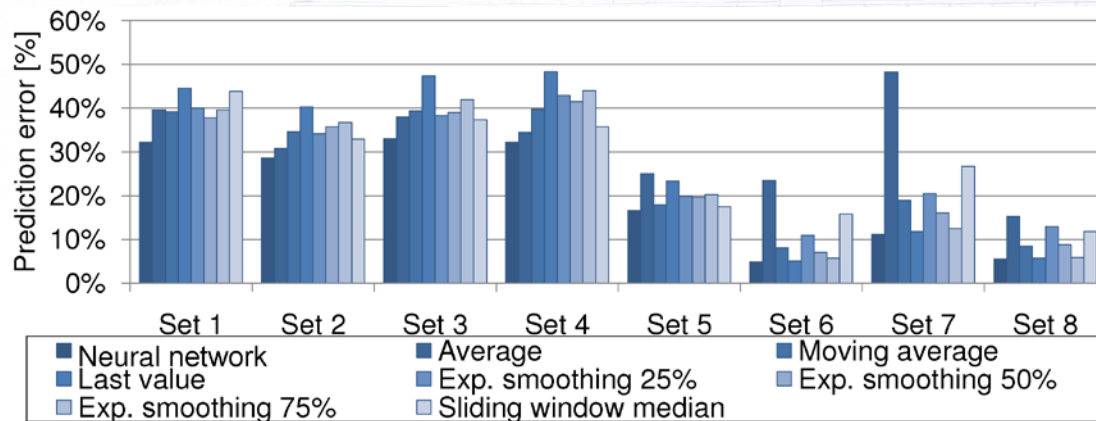 - Improve on time series-based methods
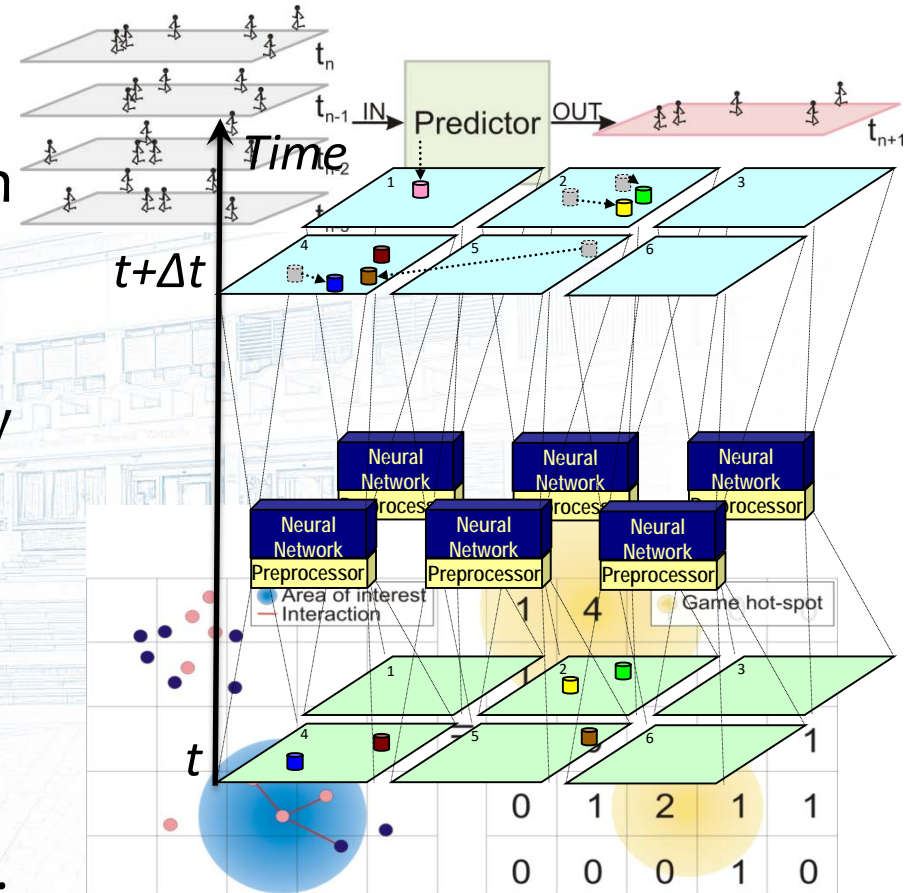
- Game simulator with different player behavioural patterns

Data set	Player behaviour [%]				Peak hours	Peak load	Overall dynamics	Instantaneous dynamics
	Achiever	Explorer	Socialiser	Killer				
Set 1	80%	10%	0%	10%	No	+++	+++++	+++
Set 2	60%	10%	0%	20%	No	+	+++	++++
Set 3	70%	20%	0%	10%	No	++++	++++	++++
Set 4	70%	30%	0%	0%	No	++	++++	+++++
Set 5	30%	40%	30%	0%	Yes	++++	++	+++
Set 6	10%	80%	10%	0%	Yes	+++++	+	+
Set 7	20%	40%	40%	0%	Yes	++++	+++++	++
Set 8	20%	80%	0%	0%	Yes	++++	+	+

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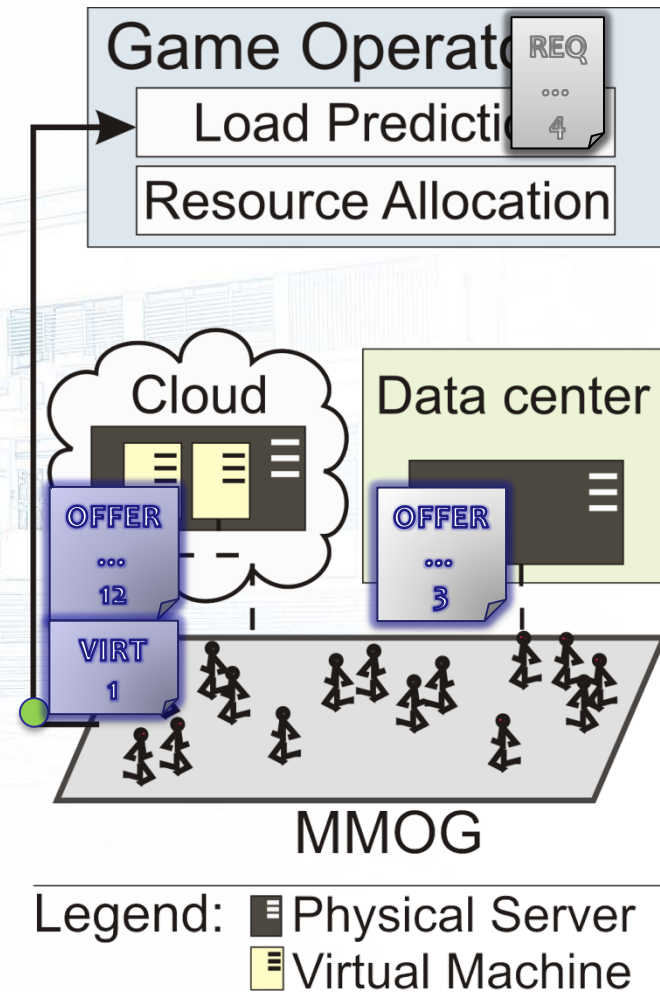
Cloud Resource Provisioning

- **Game operators** generate resource requests based on predicted load

- **Cloud providers** lease virtualized resources based on time, space, price policies

- **Resource allocation** performed through a simple matchmaking consensus algorithm
  - Locality, instance type, size, duration, price

RuneScape Resource Provisioning

- ## World's largest free MMORPG
  - 18 million active players per month (15 free + 3 members)
  - Over 200 million registered accounts since 2001

- ## 6 month long monitoring data
  - 17 data centres, 150 servers
  - 7 countries, 4 continents
  - > 130 game worlds
  - Number of player per server group at two minute interval
  - 40 million samples per simulation
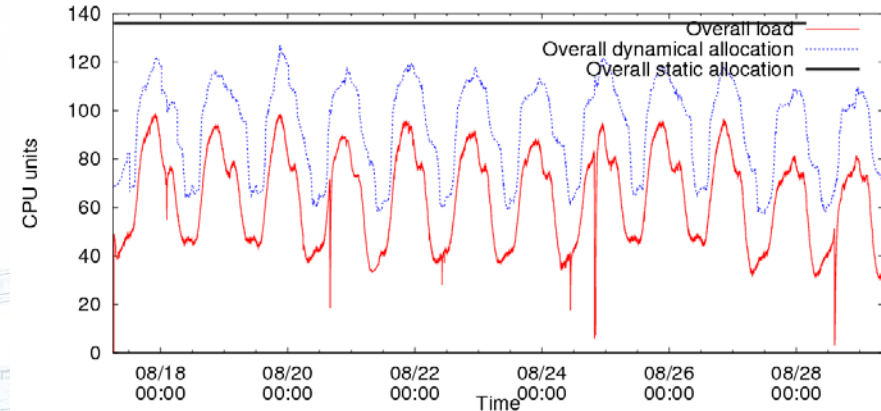
Average load	Estimated yearly MMOG hosting costs [$]					
	Amazon EC2		FlexiScale		NewServers	
	Dynamic	Static	Dynamic	Static	Dynamic	Static
0%	0	101,266	0	189,426	0	202,531
20%	23,326	101,266	40,920	189,426	38,468	202,531
50%	57,345	101,266	100,404	189,426	97,495	202,531
60%	57,830	101,266	101,829	189,426	98,179	202,531
70%	66,299	101,266	116,458	189,426	114,775	202,531
80%	75,709	101,266	133,111	189,426	129,119	202,531
90%	84,007	101,266	147,055	189,426	142,578	202,531
95%	88,199	101,266	155,039	189,426	149,793	202,531

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Massivizing Multi-Player Games... Revisited

- Edge resource provisioning for latency hiding

- Serverless games

- Real-time three dimensional rendering

- Energy efficiency on mobile devices

- Quality of experience

- Challenge of raising public research funding

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http://itec.aau.at/

THANK YOU

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