Dynamic Server Allocation in a Real-Life Deployable Communications Architecture for Networked Games

Peter Quax
Bart Cornelissen
Jeroen Dierckx
Gert Vansichem
Wim Lamotte

Hasselt University & Androme NV / Belgium

Rationale

- Request by Flemish public broadcasting company (VRT)
  - 3D virtual environments for story-telling
  - Goal :
    - Support for existing TV programs (characters, story lines,...)
    - Have people ‘create’ new content for possible future programs
  - Problems
    - Financial issues (hosting)
    - Bad experience with previous experiment
    - Success rate for programs is unknown

Identified issues

- Scalability
  - Single (massive) world is required for each story – don’t use shards or instances
  - Keep initial investment costs low, but make it easy to add capacity (unlike Second Life)
- Manageability
  - User-generated content and user actions need to be kept under control (children)
  - Designate trusted sources and parties
  - Use a client/server architecture; peer-to-peer is superior for scalability but management issues remain problematic.
- Existing solutions
  - Sun Game Server technology, MultiVerse, *Eve-online*

The ALVIC architecture

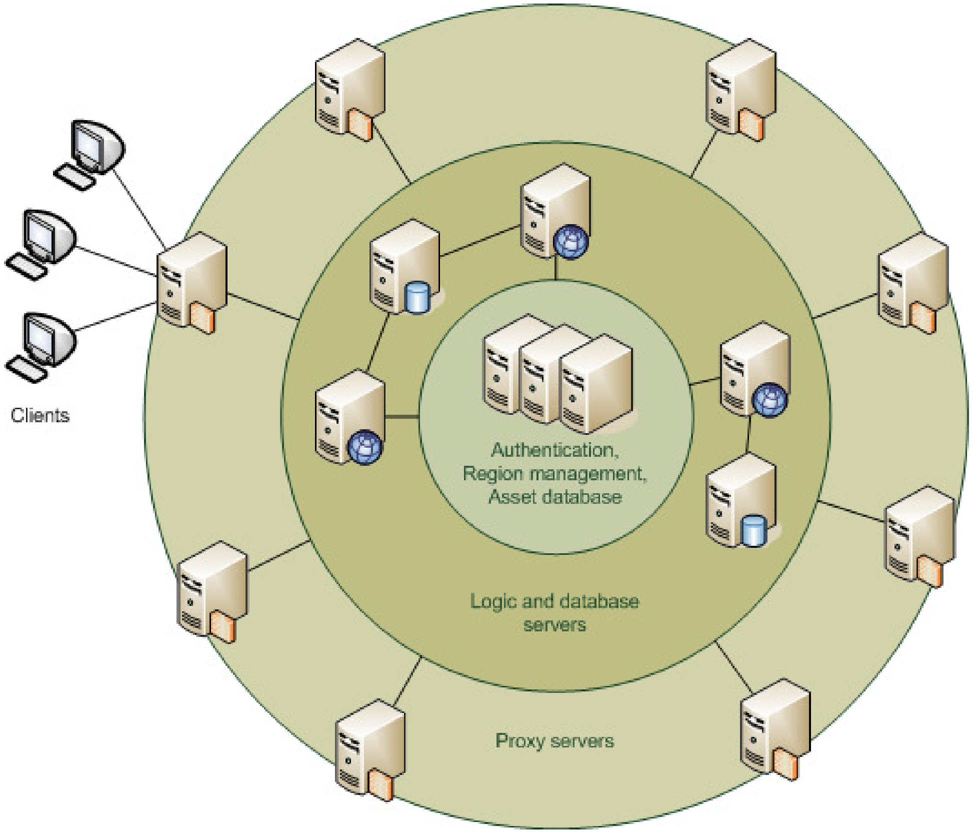
- Architecture for Large-scale Virtual Interactive Communities
  - As presented in NetGames 2003 at EA
  - Peer-to-peer system based on multicast communication
    - Spatial subdivision scheme coupled to multicast addresses
    - Clients were able to control downstream bandwidth by changing the size & shape of the area-of-interest
  - Problems
    - Required clients to be able to send multicast traffic to the WAN (or tunneling)
    - Very hard to manage from content provider point of view

Introducing ALVIC-NG

- Second generation framework
  - No longer peer-to-peer
    - Too many practical issues (deployment, consistency,...)
    - Content providers want control over the system (moderation,...)
- Should tackle the following issues
  - Efficient spatial subdivision scheme
  - Highly dynamic resource allocation at server-side
  - Minimize configuration and overhead needed at client-side

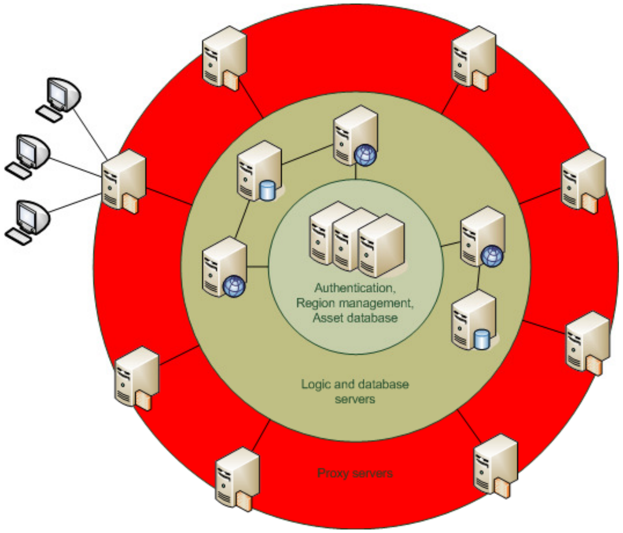
ALVIC-NG architecture

- What’s specific ?
  - Additional layer between the servers and the clients: *proxies*
  - *Region management system* (RMS) that links spatial subdivision scheme to server allocation
- Resource allocation is dynamic
  - No single central database that maintains ‘state’
  - Server infrastructure can grow dynamically depending on the # of users/subscribers -> lower initial investment



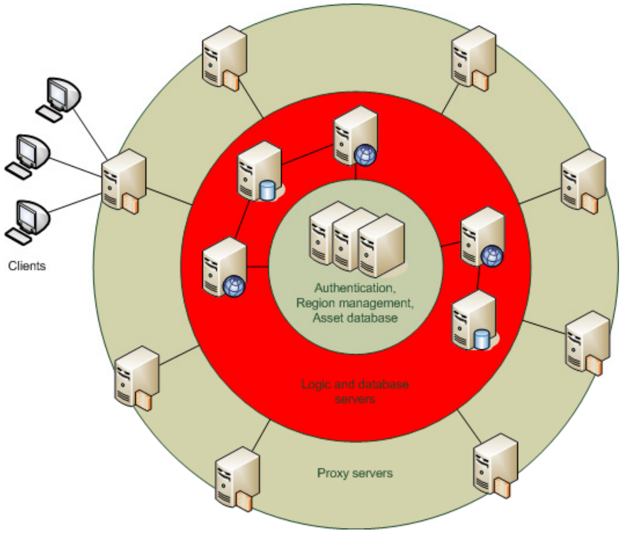
ALVIC-NG elements

- Proxy servers
  - Tunneling of traffic that is normally sent between clients and ‘world’ servers
    - Significantly reduces the # of connections for both clients and servers
    - Forwarding and packet inspection
  - Caching of data
    - Mostly non-state-related information
  - Specific proxies can be selected by client with regards to several parameters
    - Location (minimal RTT values)
    - Load (processing, network,…)
  - Pool of proxies is managed by central (trusted) entity


Authentication, Region management, Asset database
Logic and database servers
Proxy servers

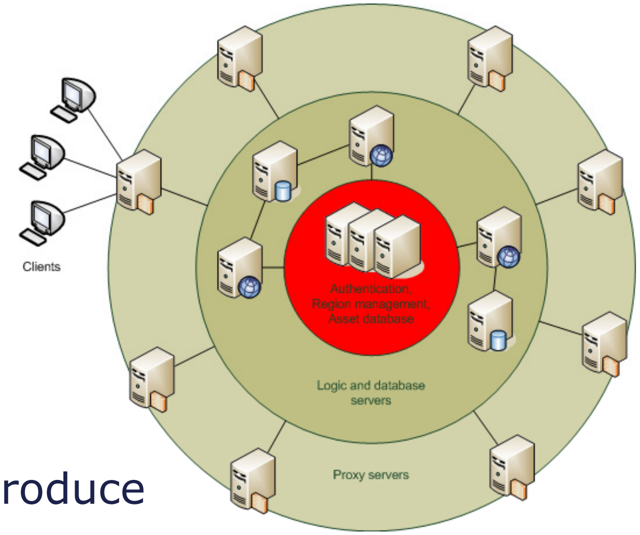
ALVIC-NG elements

- Logic servers
  - Manage parts of the virtual world
    - Keep track of object state
    - Manage NPCs by executing scripts
    - Distinguish between ‘levels’ of persistency
  - Assignment of logic servers to regions (spatial subdivision scheme) is highly dynamic
    - The system can manage if areas become overcrowded
    - References are maintained by the Region Management System (RMS)



ALVIC-NG elements

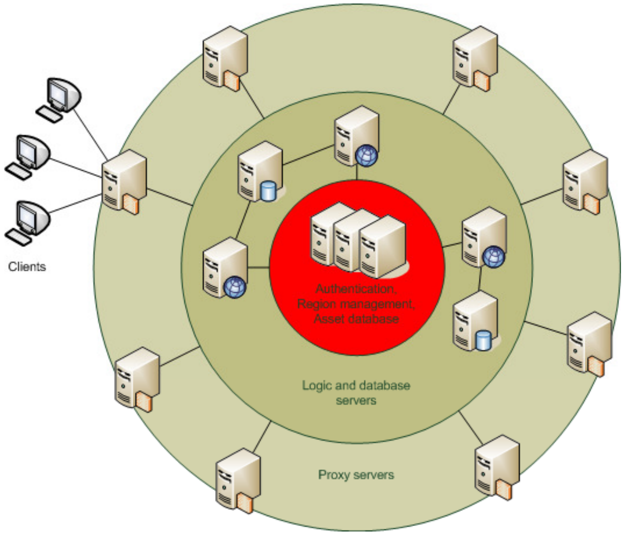
- Authentication
  - Handled by external providers
    - E.g. Electronic Identity Card
  - All servers are known to the authentication system
    - Eliminates many of the chances to introduce ‘rogue’ proxy/logic servers



- Asset database
  - Various types of elements
    - Meshes
    - Scripts for animated objects
    - Behaviors for NPCs
  - Assets are downloaded to Logic servers as needed

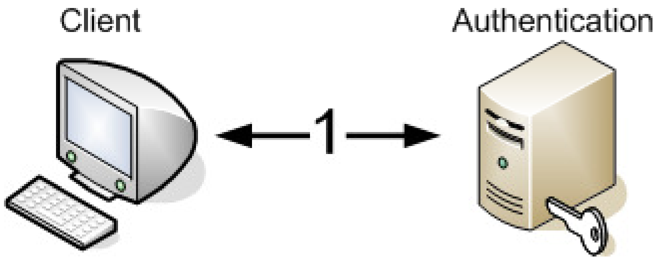
ALVIC-NG elements

- Region Management System
  - Maintains a mapping between regions and logic servers (like DNS)
  - RMS tracks several parameters
    - Load
      - Processing
      - Network usage
      - # of active clients in region
    - Exchange of information through SNMP-like protocol
  - RMS not only queries, but actively tries to resolve problems
    - Logic server failure -> assignment of region to other server(s)
    - Overcrowding -> send instructions to logic servers to split regions and update mapping tables



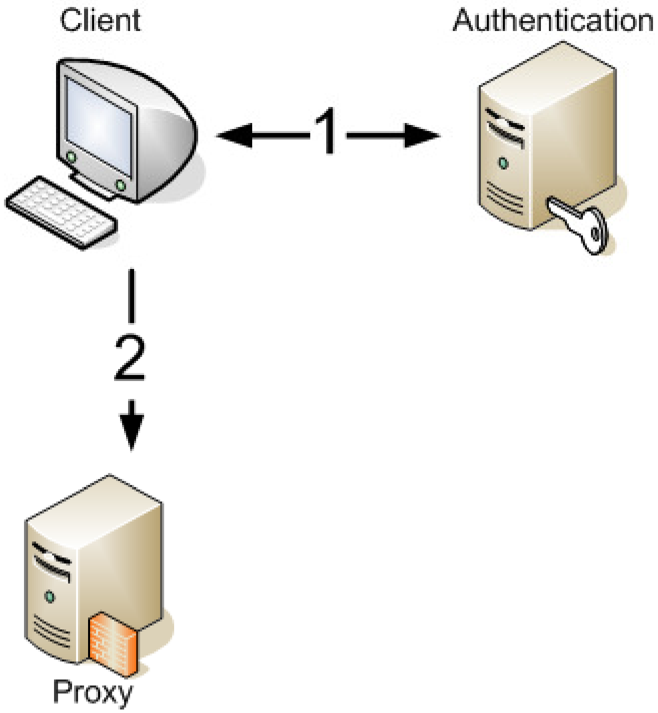
Usage Scenario

- Step 1
  - Client authenticates using his/her credentials
    - In our case : Electronic Identity Card
  - (ordered) list of available proxy servers is retrieved
    - List is also maintained by the RMS



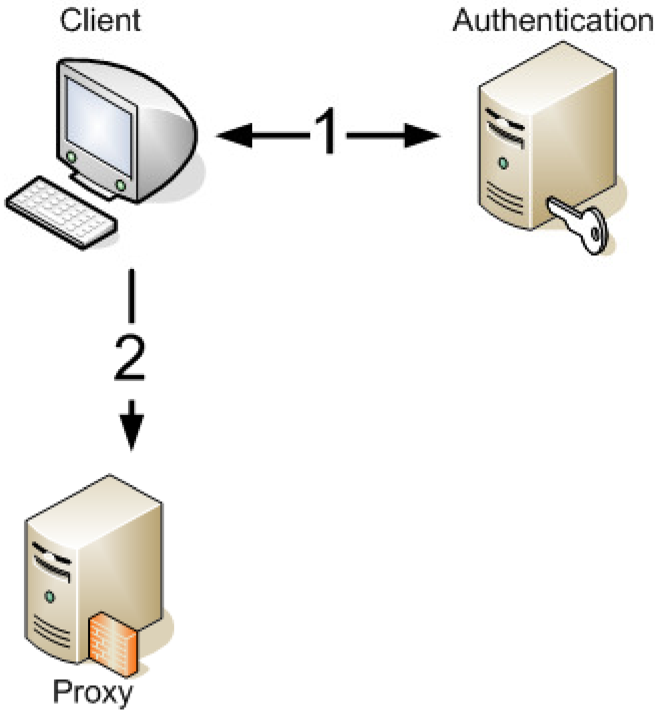
Usage Scenario

- Step 2
  - Choose the proxy server to connect to according to a metric
    - Approximate determination of delay between client and proxy based on e.g. WHOIS records
    - Current load on proxy (network,processing)



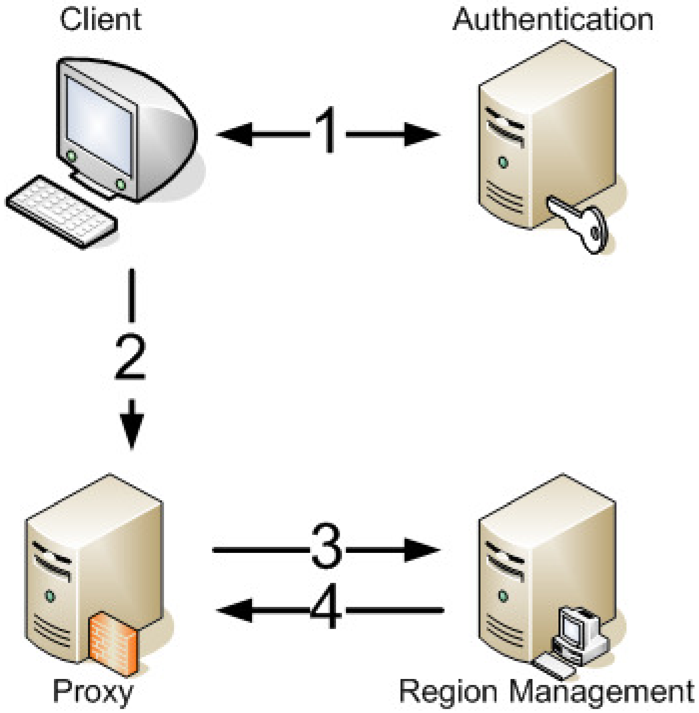
Usage Scenario

- Step 2
  - Connections to proxy are established
    - TCP connection for control
    - UDP channel for ‘bulk’ data
  - Authentication channel may be left open if needed
    - Changing keys during session



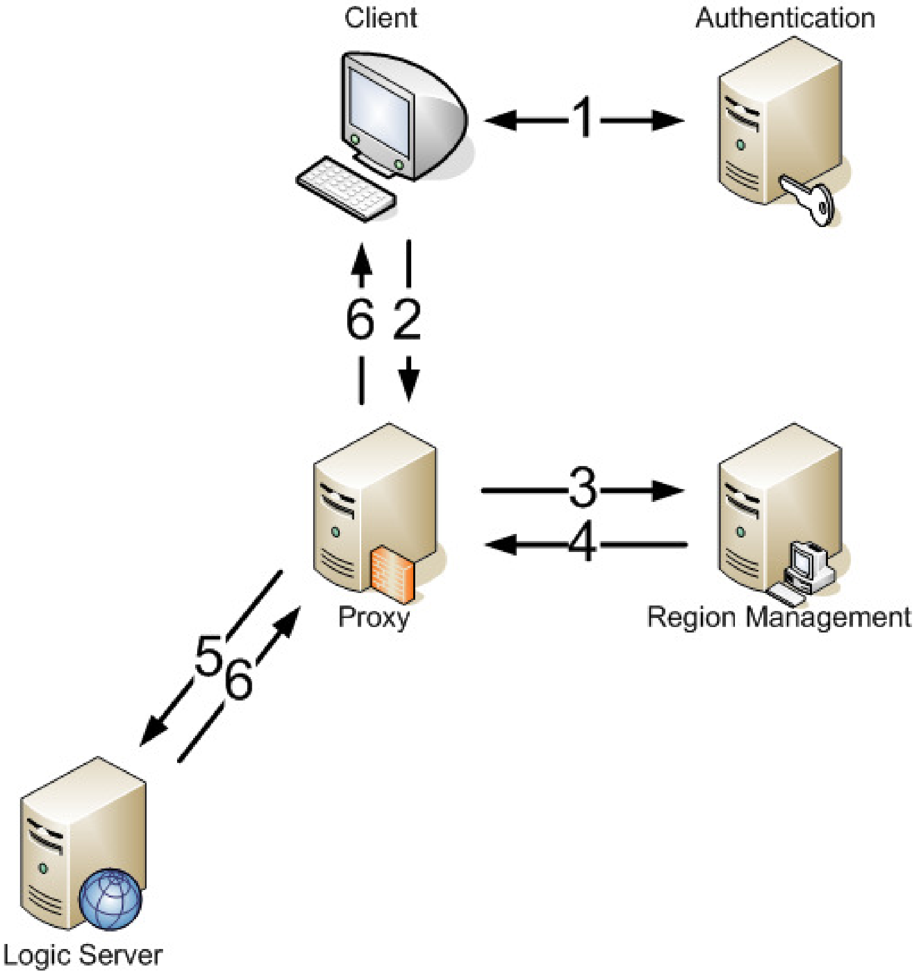
Usage Scenario

- Step 3 & 4
  - Client announces his/her position in the virtual world to the proxy
    - Client does not know about spatial subdivision scheme !
    - Proxy queries the RMS to know what Logic server is responsible for the region



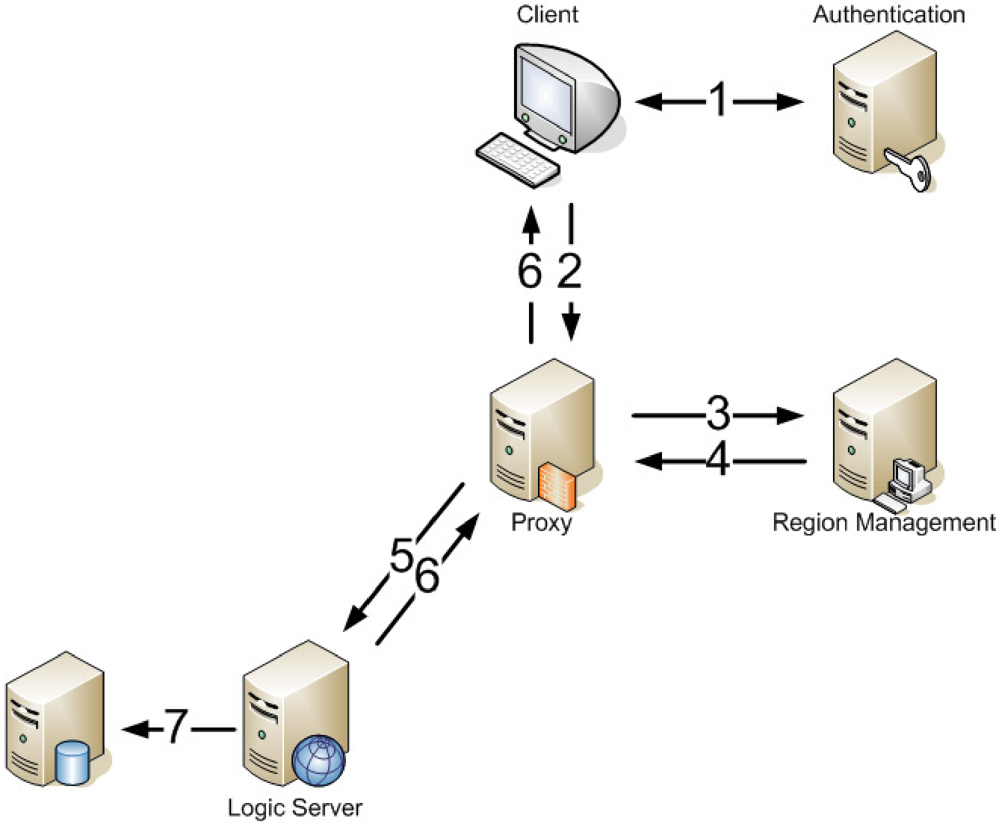
Usage Scenario

- Step 5 & 6
  - Proxy connects to Logic server that handles the part of the world the client is located in
    - State of other objects is retrieved and forwarded to the client
  - Additional connections are made as the area-of-interest changes
    - Connections no longer needed are dropped
    - # of open connections between proxies and logic servers can be optimized



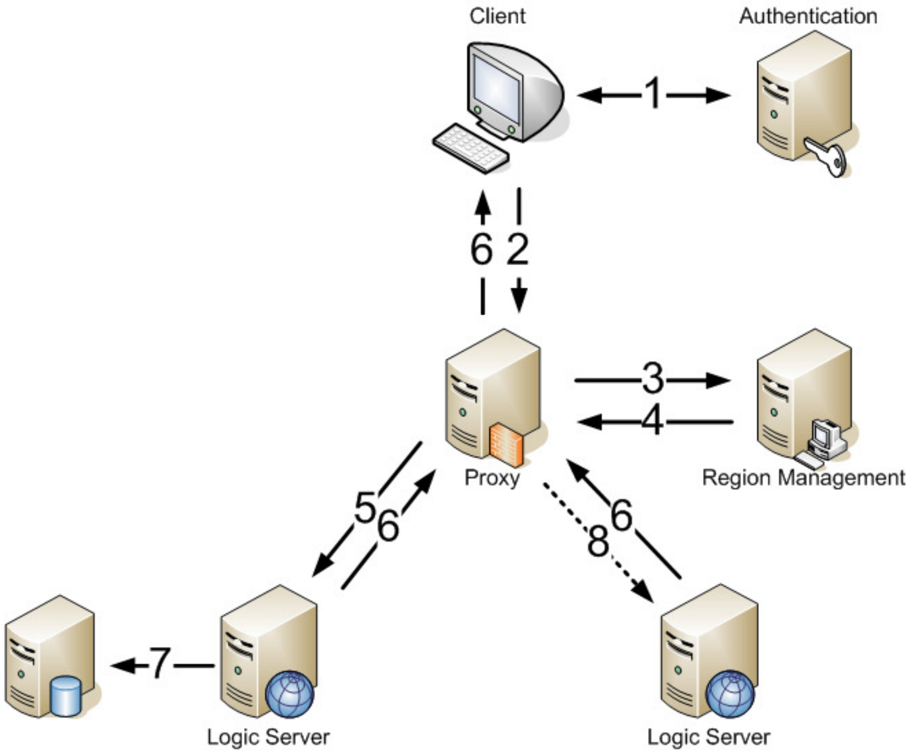
Usage Scenario

- Step 7
  - Logic server knows about the relative importance of state information
    - Some state requires frequent storage on persistent media (hard drive) -> e.g. financial transactions
    - Operations on state are handled in memory
  - Use of off-the-shelf (R)DBMS systems
    - Either 1 database system per logic server or multiple servers per database



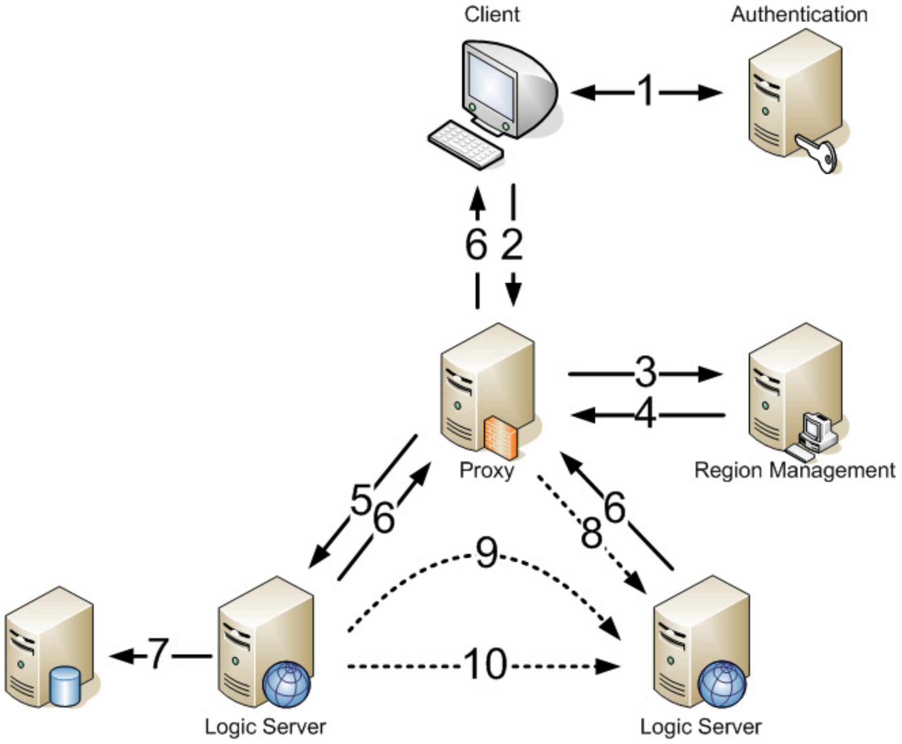
Usage Scenario

- Step 8
  - Proxy does packet inspection of ‘state’ packets sent by client
  - In case of region boundary crossing:
    - Establish connection(s) to the new logic server – if not already connected
    - Remove existing connections if no other clients require updates from the ‘old’ region
  - Spatial subdivision scheme needs to support fast boundary determination



Usage Scenario

- Step 9 and 10
  - Direct connections between logic servers are needed to :
    - Exchange state of single client at boundary crossing
    - Exchange ‘bulk’ state information when a region is split/merged or a new logic server is assigned
  - In case of logic server failure :
    - Retrieve information from the (R)DBMS system that provided persistent storage and restore state



Spatial subdivision

- Region splitting/merging is decided upon by the RMS
  - RMS has an (continually updated) global overview of the load distribution over the logic servers
  - Decisions are based on freely determined metrics, but in most cases :
    - # of clients in region
    - Processing load vs capacity
    - Bandwidth usage vs capacity
- The system does not go down when the topology changes !
  - However, a disruption in the experience is unavoidable
  - Major improvement over than the classic system (e.g. Second Life) that can not cope with overcrowding

Scalability testing

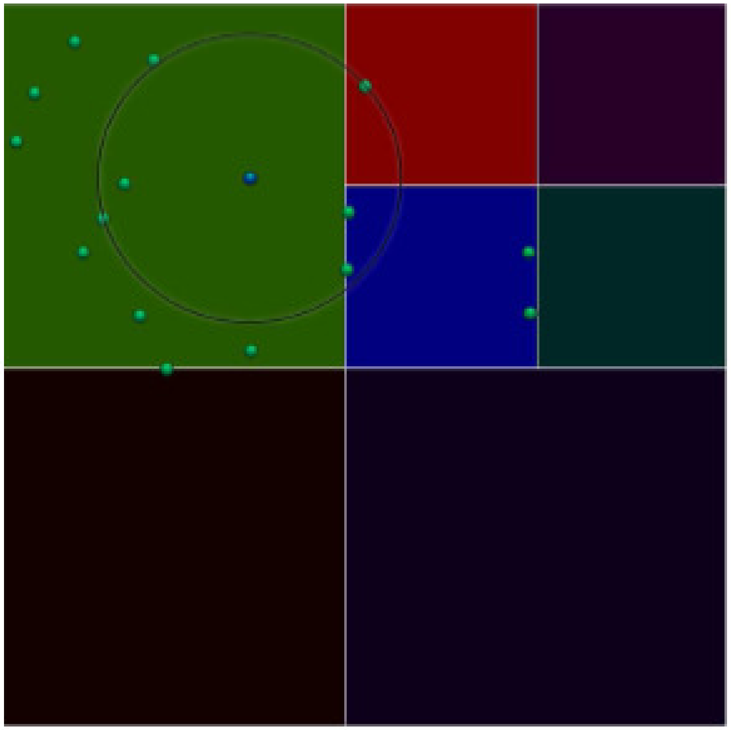
- Determine the overhead introduced by additional components (proxies)
  - Each proxy server has to support a large # of users
    - Economic impact (additional cost)
    - Reduced # of connections for logic servers
  - Without proxies, the system resembles traditional approaches
- How to determine overhead
  1. Modeling the bandwidth usage/processing requirements
  2. Test setups that come close to real life -> simulation
- Advantages of simulation
  - Make sure that the implementation works
  - Modeling can overlook certain issues

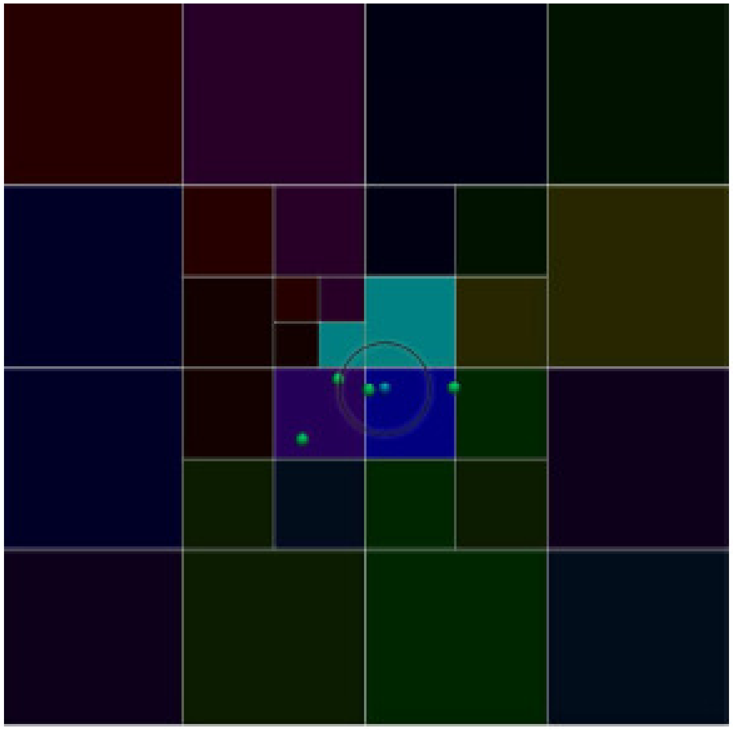
Scalability testing

- Use the actual client software
  - But strip the 3D visualization
  - Control all instances through a central process (Bot Server)
  - Individual clients behave under control of LUA scripts -> randomness
- Execution
  - Run large number of concurrent processes on a dedicated cluster
  - Use the actual implementations of the various servers

Scalability testing

- Visual check of simulation
  - Single client application that is controlled by human operator
  - Can provide overview of spatial subdivision scheme and client distribution





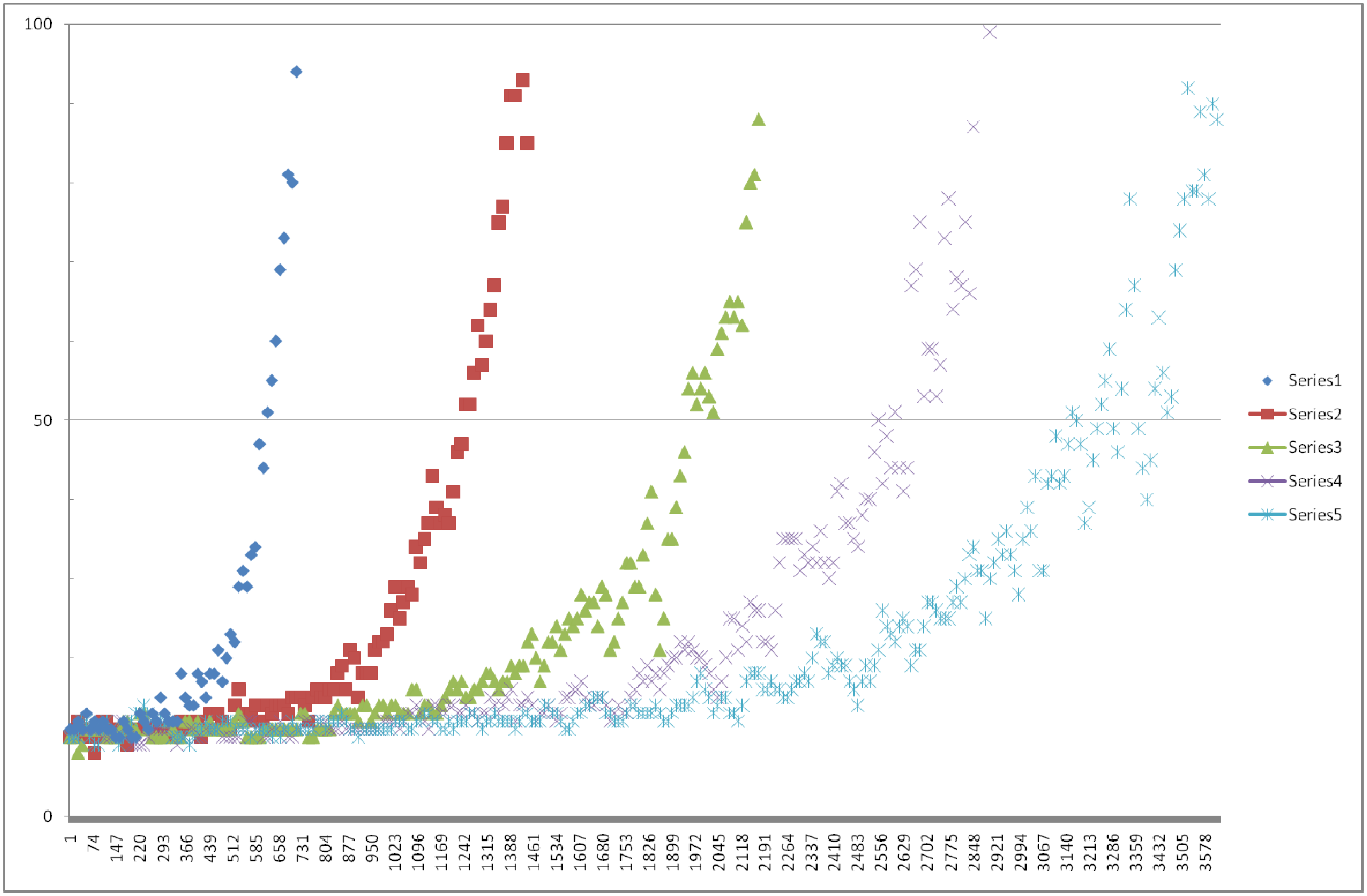
Scalability testing

- Load on logic servers is not examined
  - Is heavily dependent on the type of application
    - Player-player interactions vs. NPC behaviors
  - There is existing work that can be referred to
    - Results will be at least as good as in existing work, as fewer connections need to be managed
- Simulation parameters
  - Use a state update rate of 3 per second
    - A ‘smoothing’ algorithm is often used/required (e.g. dead reckoning)
    - Value is representative for real-life applications
  - RTT is the “load” metric, not raw CPU usage
    - RTT measured between the “send” action of the client and the reception of an echo of the update
    - Network delay on the Gbit LAN is negligible – nearly all delay is introduced by software
  - Cut-off value for interactivity = 50 ms
    - Seems rather low, but does not include network-induced delay

Scalability testing

- Tests runs
  - Scenarios with between one and five proxies
  - Each run is repeated five times to even out the results
  - Randomness is guaranteed by the scripted behaviors
- Connections between client instances and proxies are established in round-robin
  - Ensures an even load on the proxies
- Test results show absolute figures
  - In practice, trends are more important
  - Cluster is made up of relatively low-end hardware

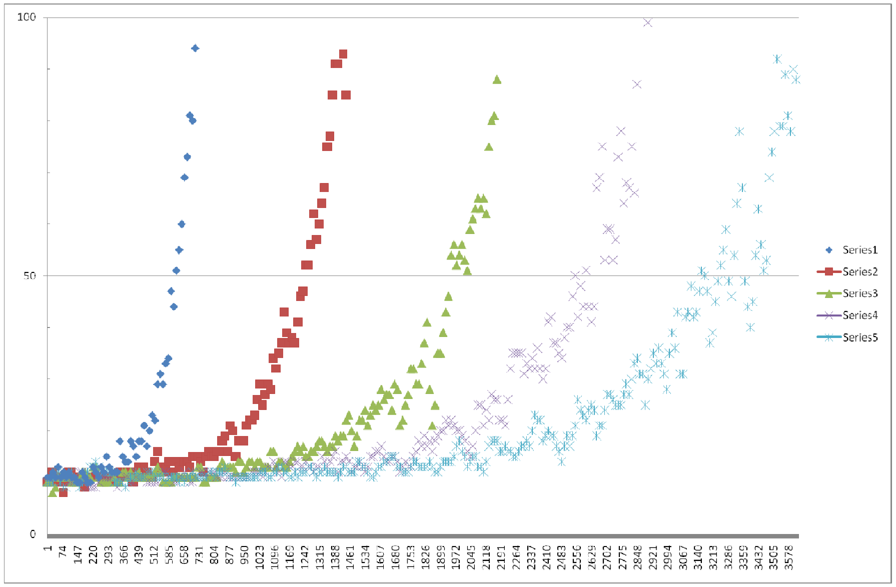
Result 1 :
# of clients vs # of proxies



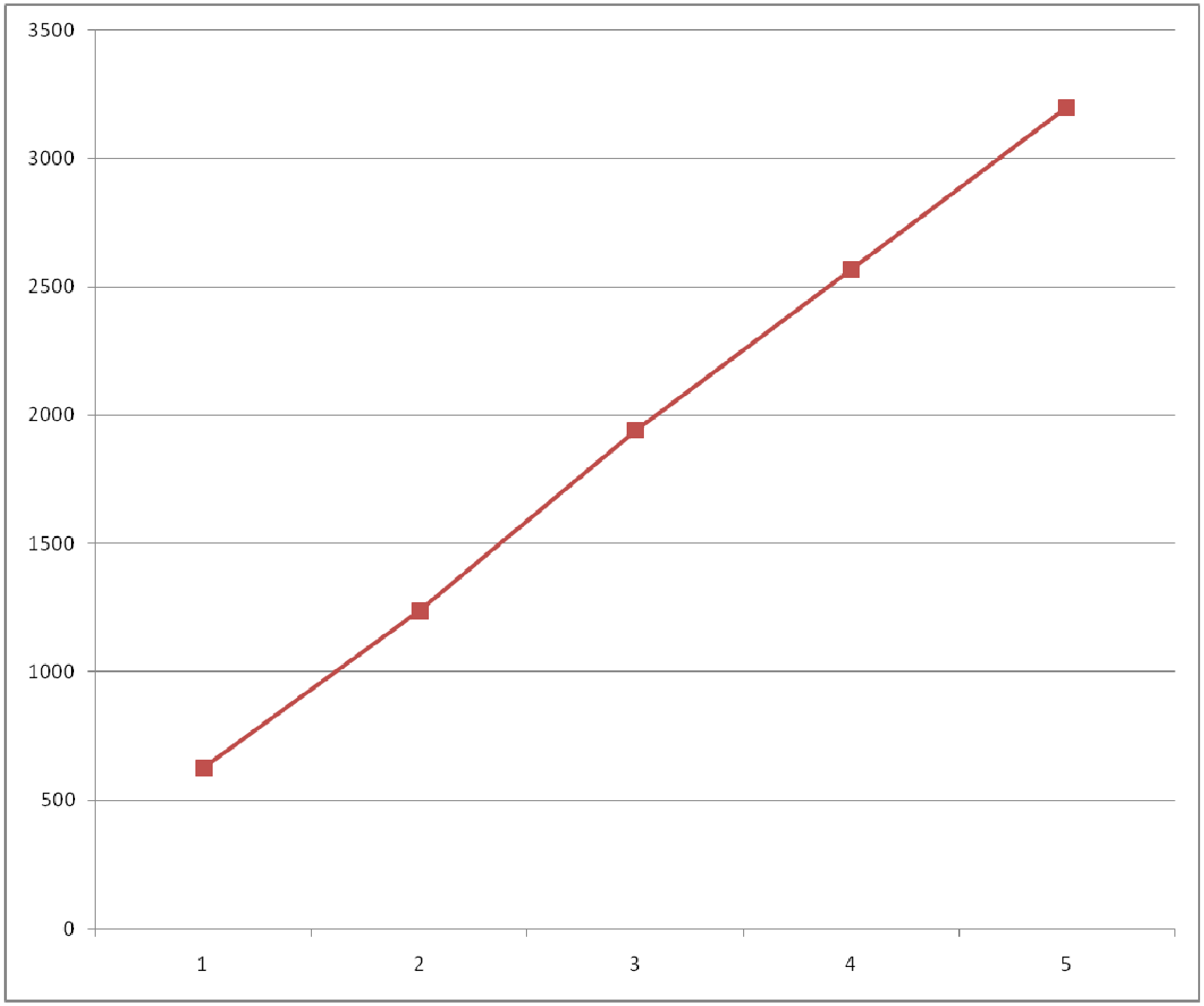
Result 1 :
# of clients vs # of proxies

partner in IBBT

- Parameters
  - Data points are sampled at 10 second intervals
  - Each bot server spawns at least 1 client per second
  - # of bot servers equals # of proxies
- Observations
  - Simulation with 1 proxy gets overloaded around 625 clients

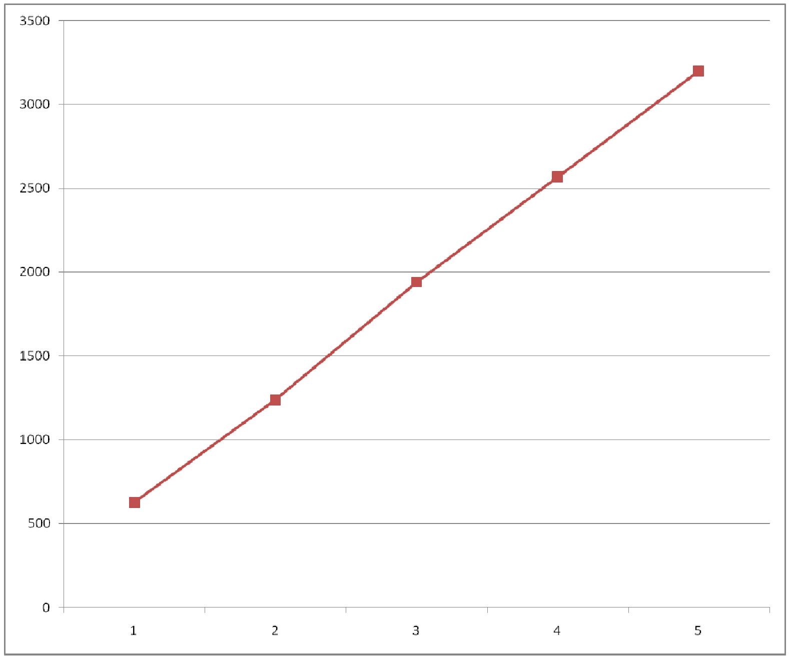


Result 2 : acceptable # of clients vs # of proxies

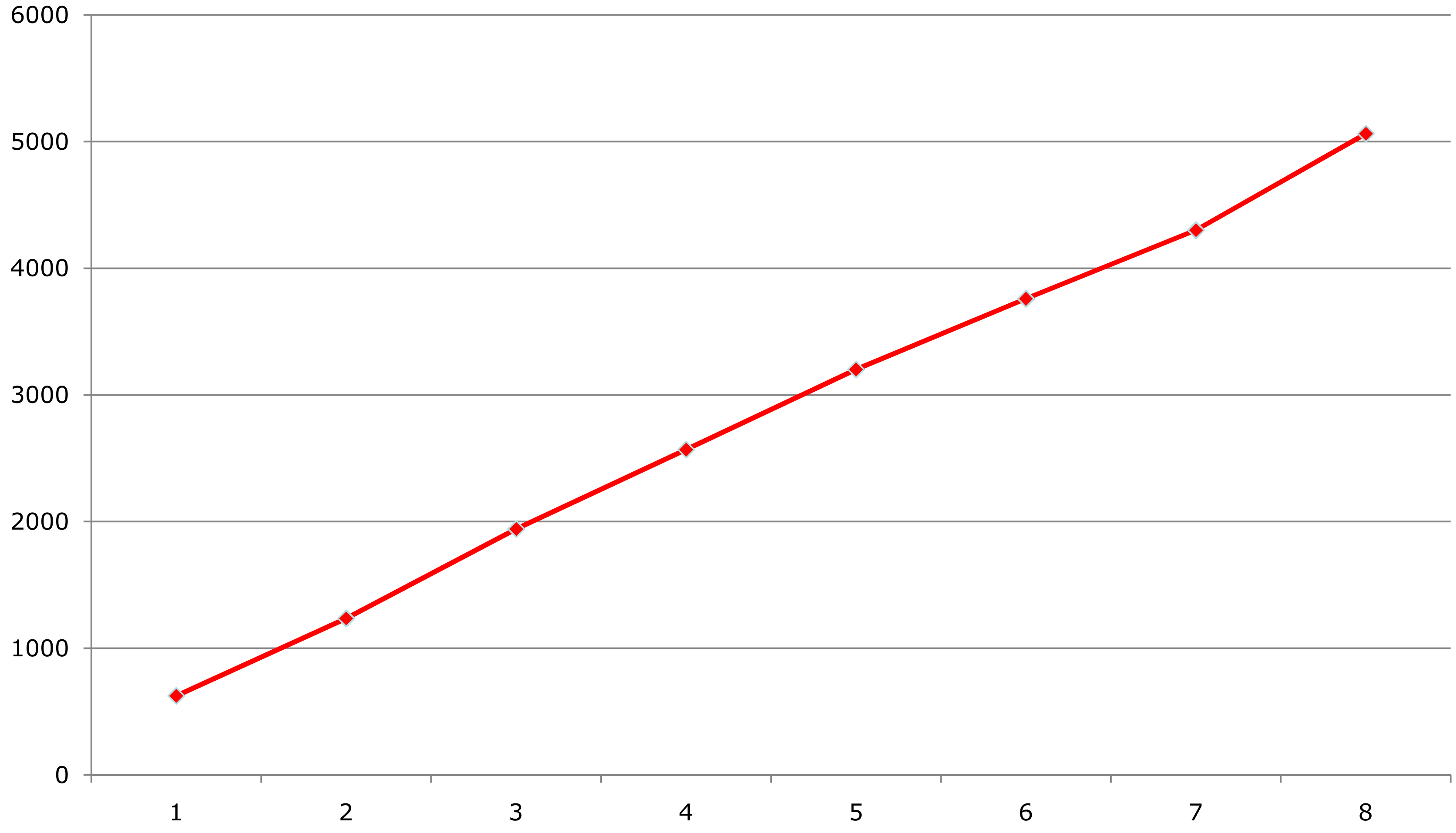


Acceptable # of clients given # of proxies

- Parameters
  - Interactivity threshold of 50 ms
- Observations
  - Scales nearly linear between scenarios
  - Good indication that scalability is ensured



Extended test



Future Work

- Next steps
  - Re-run tests on a 100+ node cluster
  - ALVIC-NG also includes a conferencing system
    - Based on similar spatial subdivision scheme
    - Can efficiently distribute audio/video streams between large # of participants