Peer-to-Peer Content Delivery for X3D Earth

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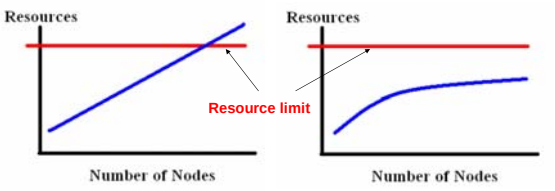
2006/11/14

X3D Earth Scalability

- *X3D Earth* is an ambitious project
- "The key challenge is scalability"
  -- Don Brutzman, "X3D Earth Proposal"
- A simple math:
  - 80 kbps (10kb) x 100,000 users = **1 GB / s**

Scalability Analysis



Non-scalable systems vs. Scalable systems

Potential Solutions

- Data compression & progressive transmissions
  - Doable and necessary
  - Server load still increases for each additional client
- Content Delivery Network (CDN) e.g. Akamai
  - High infrastructure costs
  - Adoptable only by big players
- *Any alternatives?*

overlapped visibility = shared contents

Promises of P2P

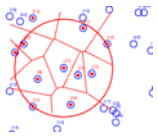
- Scalable
  - Growing resources, decentralized
- Affordable
  - Commodity hardware
- Examples:
  - File-sharing: Kazza (3 M users, 5,000 TB / day)
  - VoIP: Skype (3.5 ~ 4M users any moment)

Challenges of *P2P* 3D streaming

- Limited client-side bandwidth
  - Typical end-system is asymmetric (small upload)
  - BitTorrent achieves 30KB/s ~ 50KB/s avg. download
- NAT-traversal
  - NAT-boxes are very common
  - Practical solutions exist
- Peer and piece selection
  - Find the right peers to connect, and pieces to obtain
  - Research still required for efficient solutions

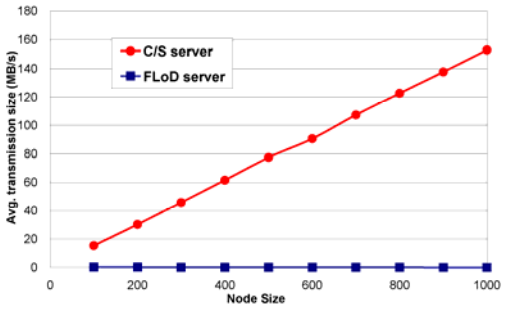
Our Capabilities

- P2P-based virtual environments research
  - *Voronoi-based Overlay Network* (VON)
  - IEEE Network publication (July 06)

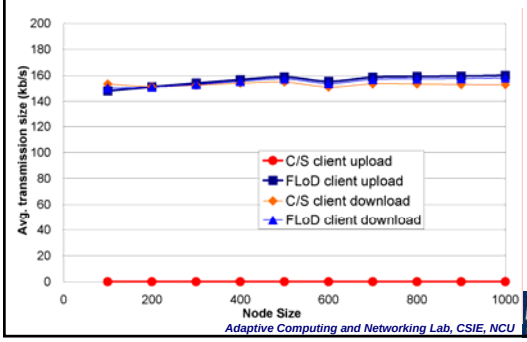


- P2P-based 3D streaming research
  - *Flowing Level-of-Details* (FLoD)
  - Initial results soon to release as technical report

Simulations (server bandwidth use)



Simulations (client bandwidth use)



Conclusion

- Scalability is a core X3D Earth challenge
- P2P is the most sensible delivery choice
- Related issues are practically addressable

Final remarks

People in this business tend to fixate on the technology side of things. The technology side is actually really easy. You can predict what's going to work technologically and what's not going to work. The thing that's hard — and the thing that most people don't want to admit is the hard part — is the social experiment. What is it that people want? -- James Gosling

- Make X3D Earth the *social experiment platform* for virtual worlds / environments
- Multi-user is easily extensible with P2P

References

- Kazza
  - Jian Liang et al. “Pollution in P2P File Sharing Systems,” Proc. INFOCOM, 2005
- Skype
  - Kuan-Ta Chen et al. “Quantifying Skype User Satisfaction,” Proc. SIGCOMM 2006
- Voronoi-based Overlay Network
  - Shun-Yun Hu et al. “VON- a scalable peer-to-peer network for virtual environments,” IEEE Network, 2006