Pangolin –
Speedy Messaging for Cloud-based Social Gaming

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Cloud-based Social Gaming is on Fire

Zynga Said to Plan IPO Valuing It at as High as $10 Billion

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The Network Latency Problem

- Massive players at the edge & with very diversified connectivity
- Game logic in a centralized cloud
- Games highly interactive, players extremely sensitive to latency

How to ensure universally smooth gaming experience?
Bounding the tail performance!
Xbox Live Social Game – 1vs100

- Massive number (100K+) of concurrent players
- Answer multiple-choice questions
Which late-night talk show host finally tied the knot in March 2009?

- David Letterman
- Jimmy Kimmel
- Conan O'Brien
Xbox Live Social Game – 1vs100

- Game SLA: make 99.9% players happy
- Interaction gap: up to 5 seconds
Xbox Live Social Game – 1vs100

• Production environment before Pangolin
  • Xbox consoles exchanging short messages (2KB) with the Cloud
  • All messages based on TCP
  • Game only open to US, CAN and Europe players
  • Desirable deadline – 1.5 seconds

• Unfortunately, many messages arriving late
Real-World Measurement

- In-game measurement engine
- Low rate packet probes from 1% of Xbox consoles
- Collected packet level traces replayed in lab

- US/CAN & Europe only
- Imagine what’s next
  - open to all markets
  - launch on mobile
Conclusions from Real-World Measurement

• RTT variation and packet loss are the culprits

• Problem cannot be solved w/o packet redundancy
  • Fixing TCP isn’t gonna cut it!

• A new transport protocol (UDP + FEC) is necessary
Forward Error Correction 101

* picture by courtesy L. Rizzo
Challenges

• Adaptive solution
  • Avoid self-congesting network
  • Reduce cloud bandwidth consumption

• Low complexity
  • Gaming servers have many tasks in plate
Problem Formulation

- Objectives
  - Given latency threshold
  - Message success rate $\geq 99.9\%$
  - Minimize redundancy
Markov Decision Process (MDP) Formulation

- **Definitions**
  - state - the number of packets remaining at a stage
  - action - the number of packets to send, given the state
  - a policy – map states to actions

For a given policy, we can easily compute
- success rate
- redundancy
Solving MDP

- The MDP problem – find an optimal FEC policy
  - minimizes the expected redundancy
  - while satisfying success rate (≥ 99.9%)
  - within the target latency T
- Compute using Dynamic Programming
Low Complexity Implementation

• Given packet loss rate, all optimal polices can be derived

• Pack all optimal policies into a look-up table
  • Packet loss rate
  • Ratio between latency threshold and RTT
  • Stage
Evaluation

Pangolin redundancy – only 6.1%!
Summary

• Pangolin: a speedy messaging protocol for cloud-based social gaming

• Adaptive FEC with low complexity implementation

• Released in Xbox SDK, used by millions of users and many game titles
Related Work

• Real-time communications – degradable multimedia
  • Video conferencing (Rhee’98)
  • VoIP (Bolot’99)
  • Streaming Video (Chou’01, Chang’09)
• Bulk data transfer – throughput
  • Reliable multicast (Nonnenmacher’98, Rubenstein’04)
  • Digital fountains (Byers’98, ’02, Maymounkov’03)
  • Network coding (Chou’03, Gkantsidis’06)
• Short transfer – no degradable, latency messaging
  • Balakrishnan’07 ’08
  • Pangolin address this class of problems