

# Pangolin – Speedy Messaging for Cloud-based Social Gaming

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# Cloud-based Social Gaming is on Fire



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By Douglas MacMillan and Lee Spears - Dec 1, 2011 7:15 AM PT

# 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

Bob Loblaw Esq



5,260

malloc2



5,420

Bastelyon



3,665

Phoenix2



5,480

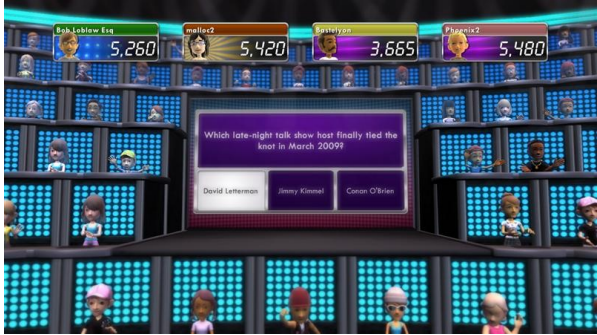
Which late-night talk show host finally tied the knot in March 2009?

David Letterman

Jimmy Kimmel

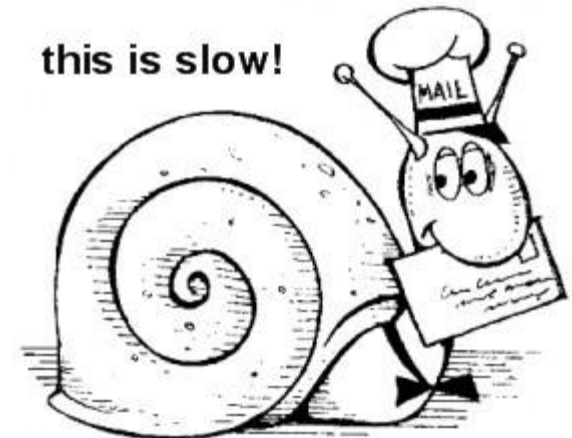
Conan O'Brien

# Xbox Live Social Game – 1vs100



interaction gap

- Game SLA: make 99.9% players happy
- Interaction gap: up to 5 seconds

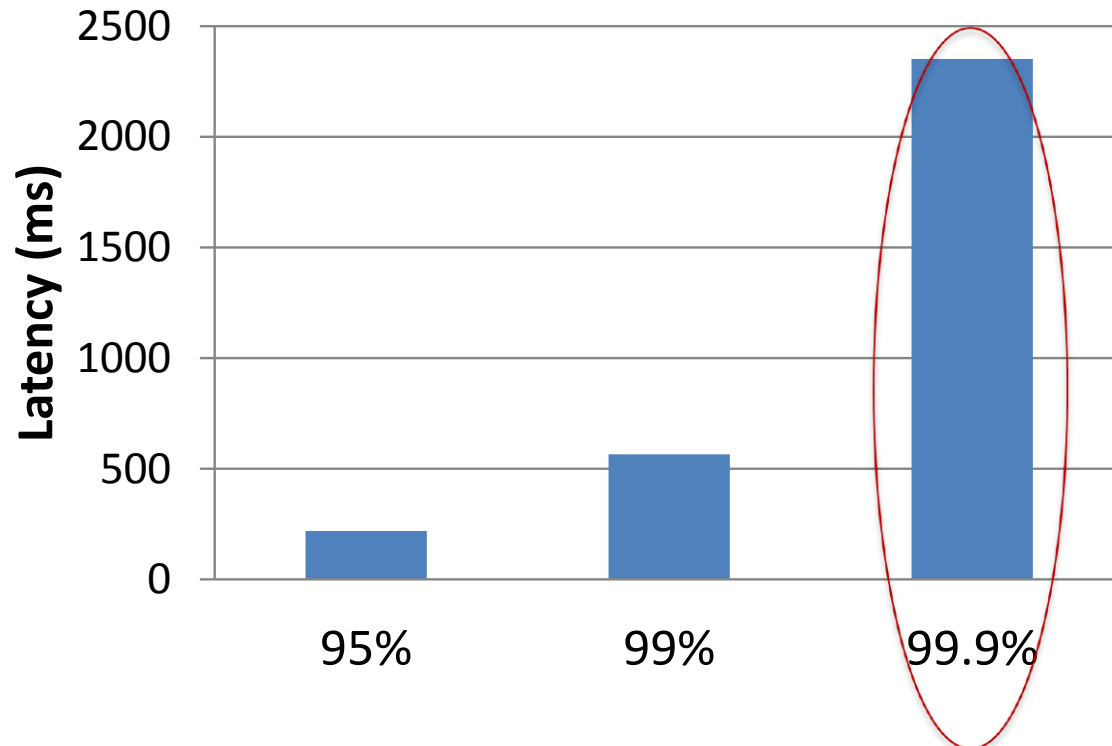


# Xbox Live Social Game – 1vs100

- 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

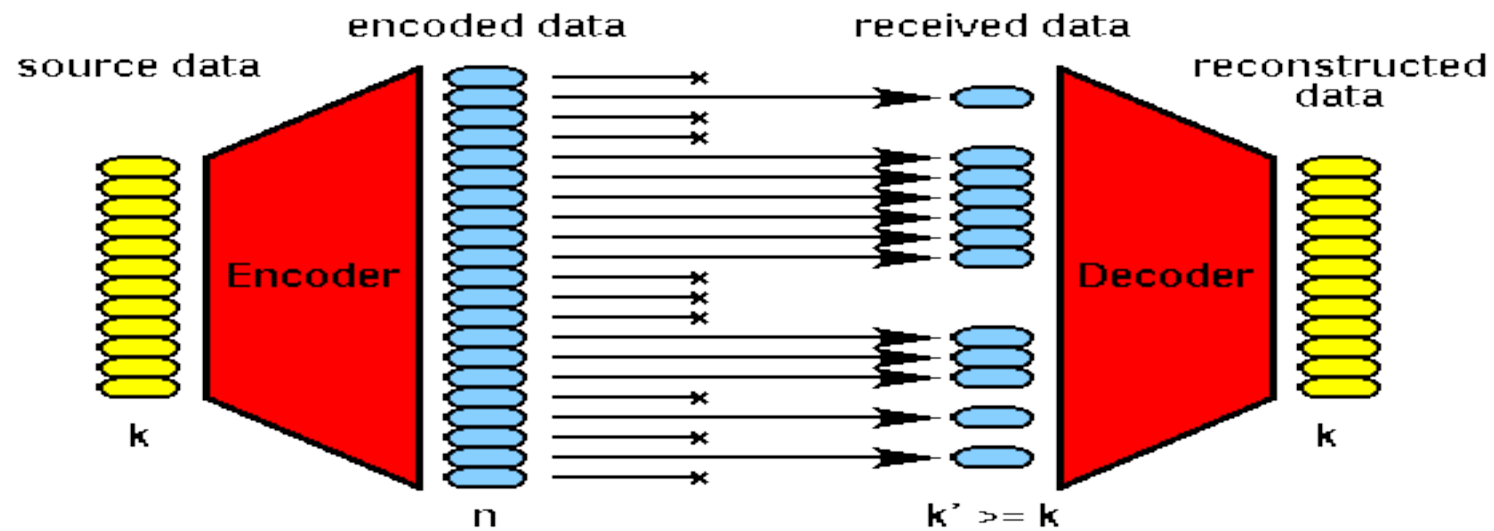


- US/CAN & Europe only
- Imagine what's next
  - open to all markets
  - launch on mobile

# 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



# 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

4

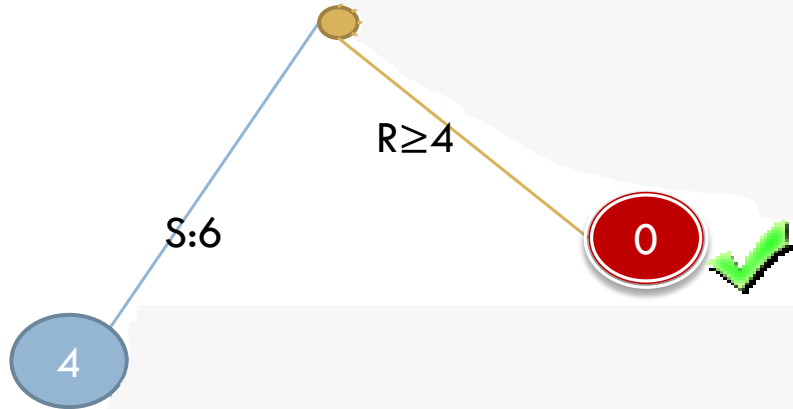
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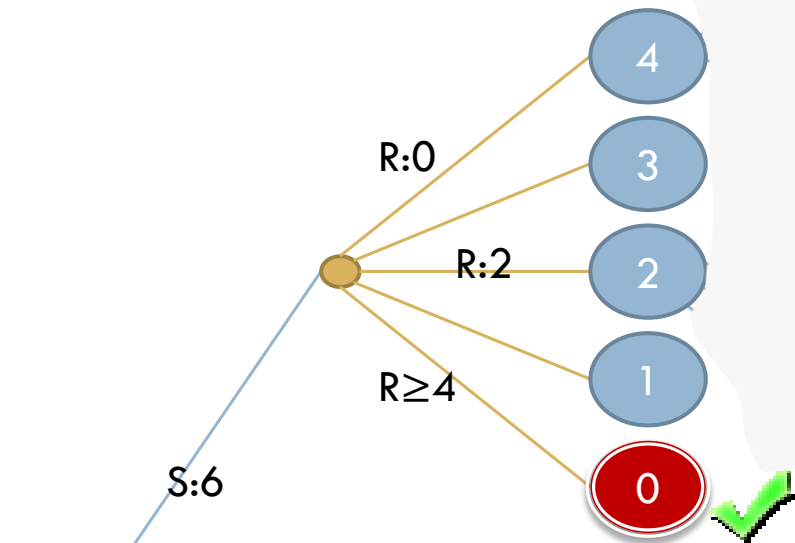
RTT

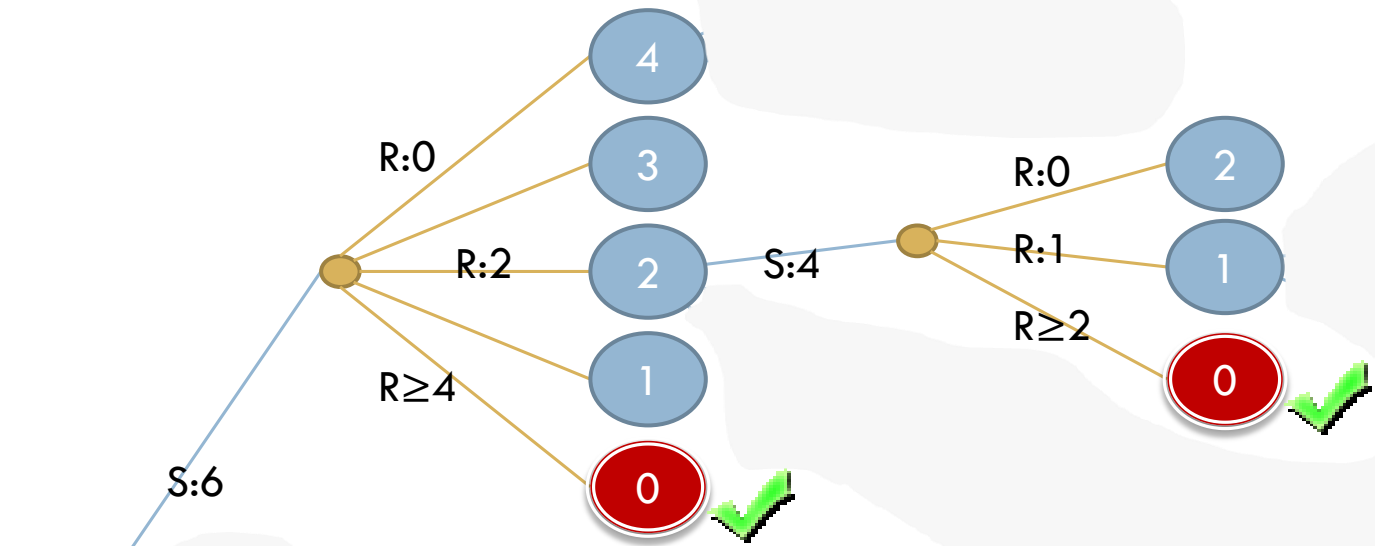
2RTT

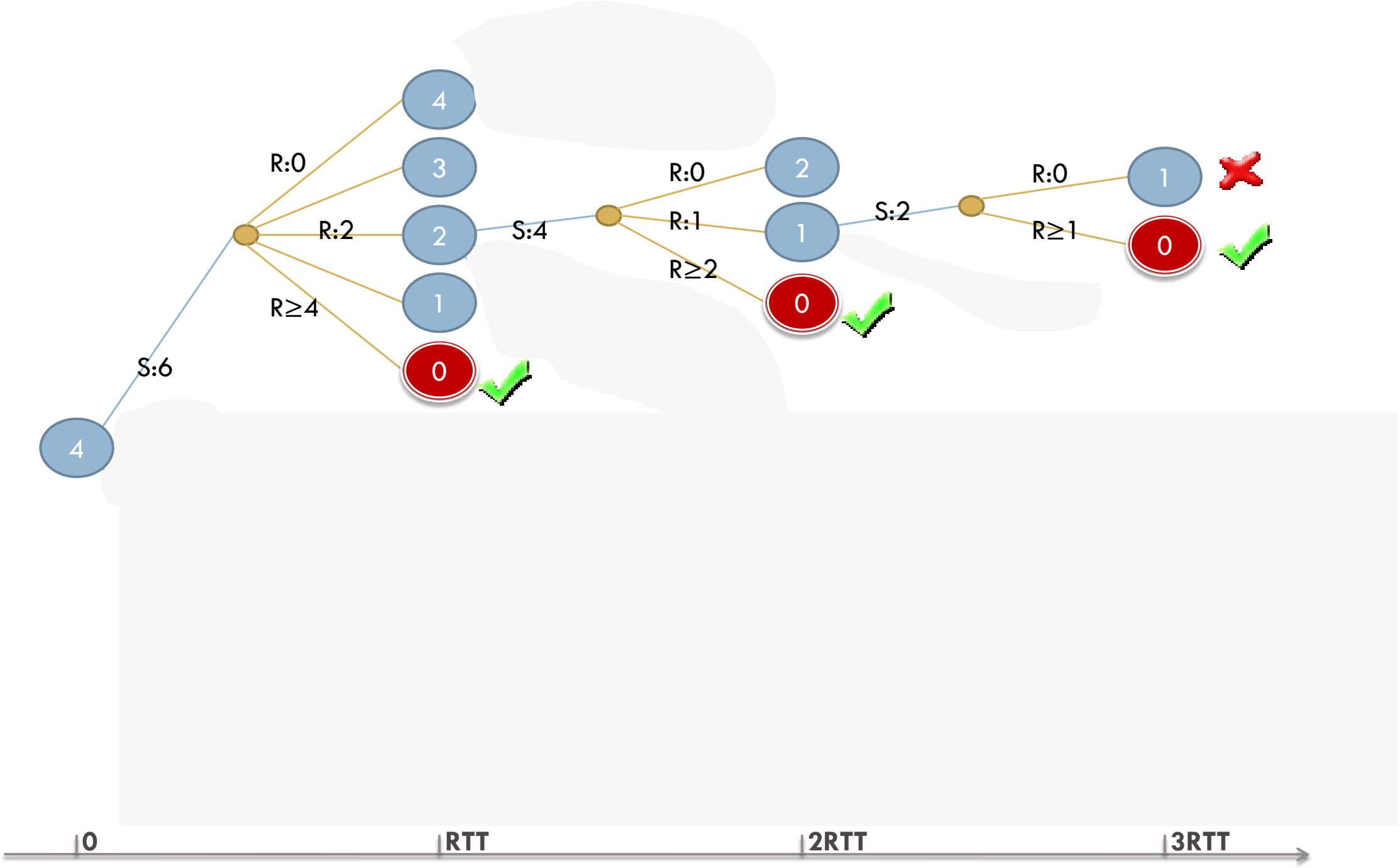
3RTT

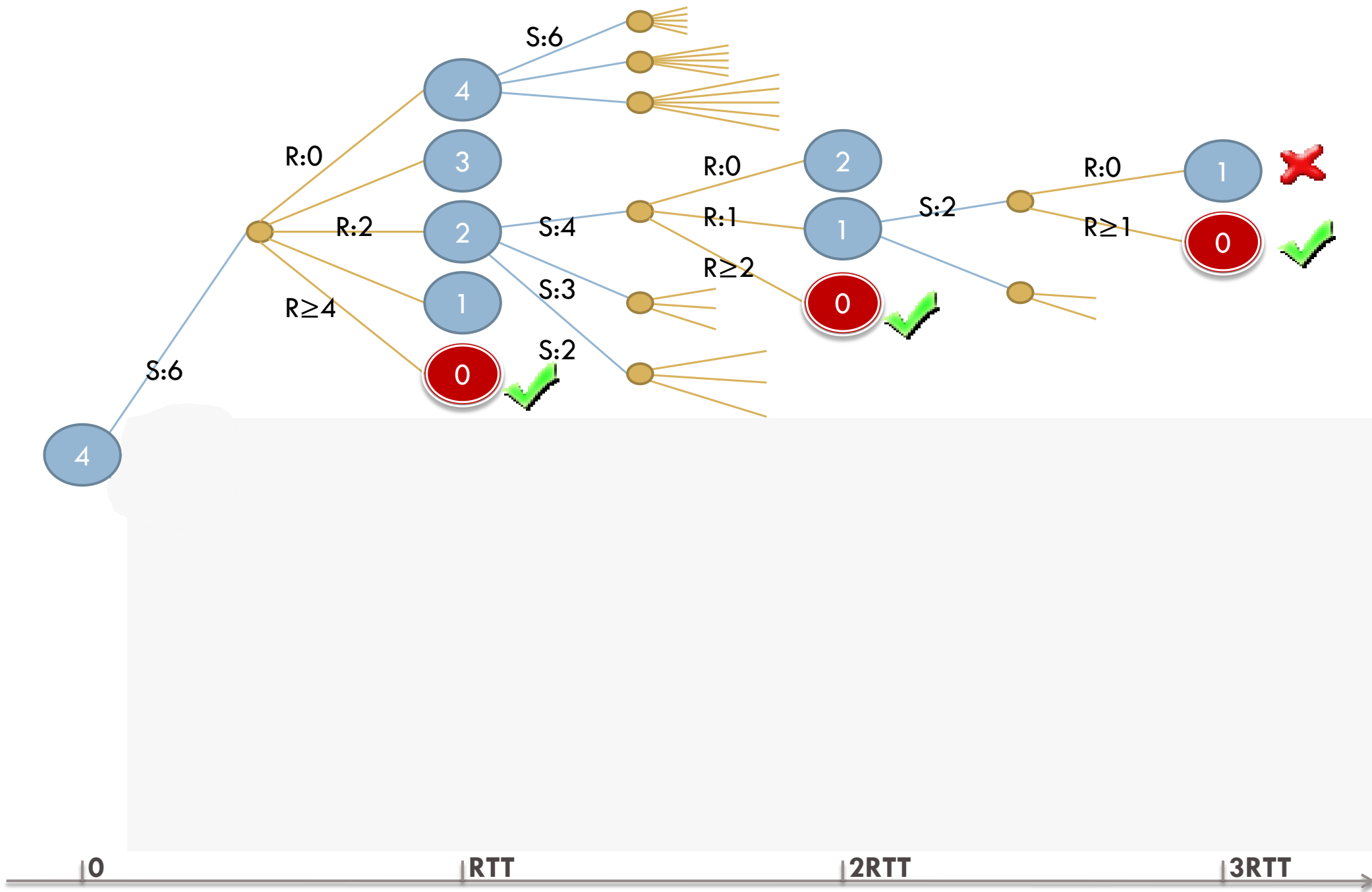


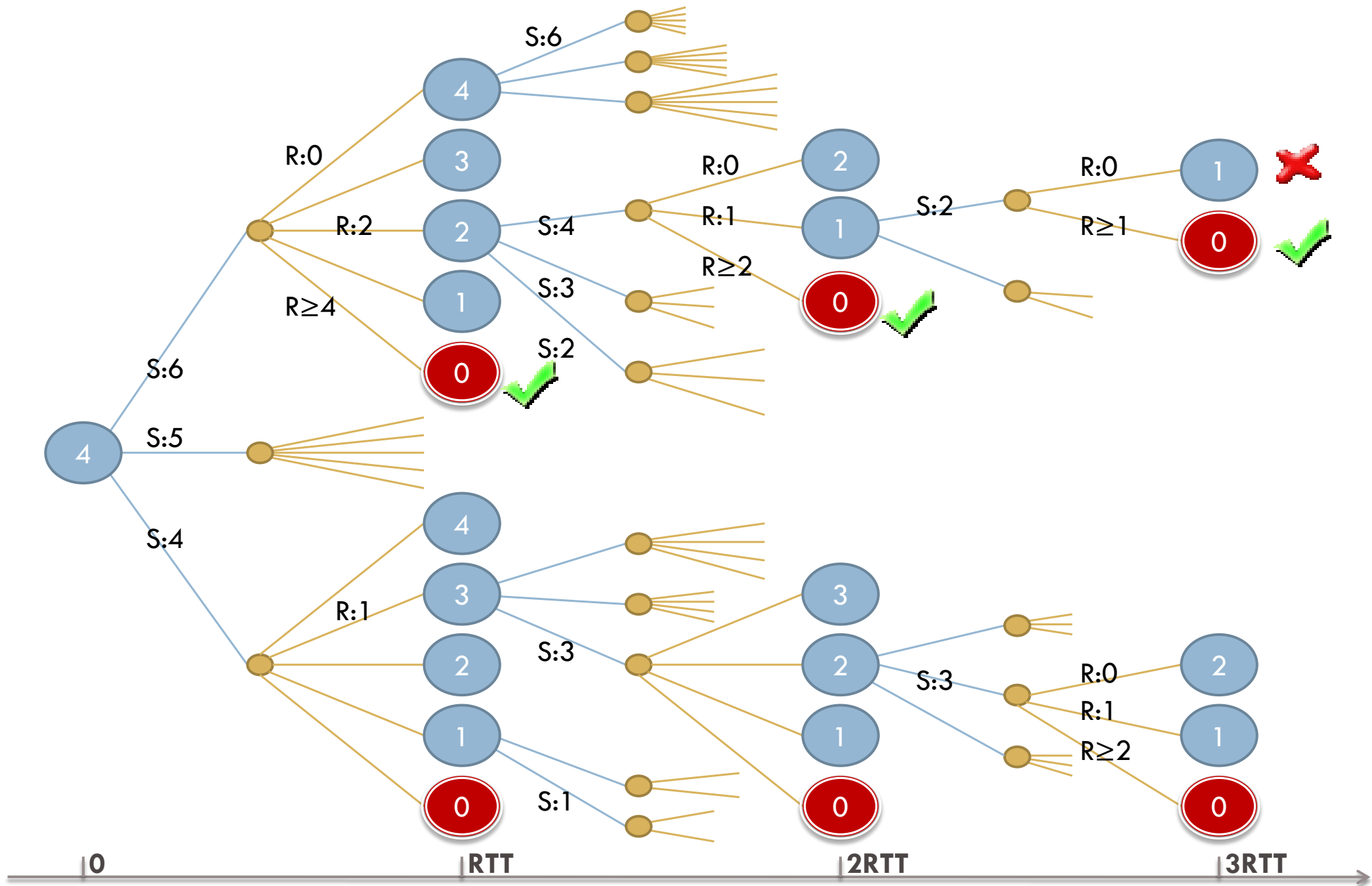




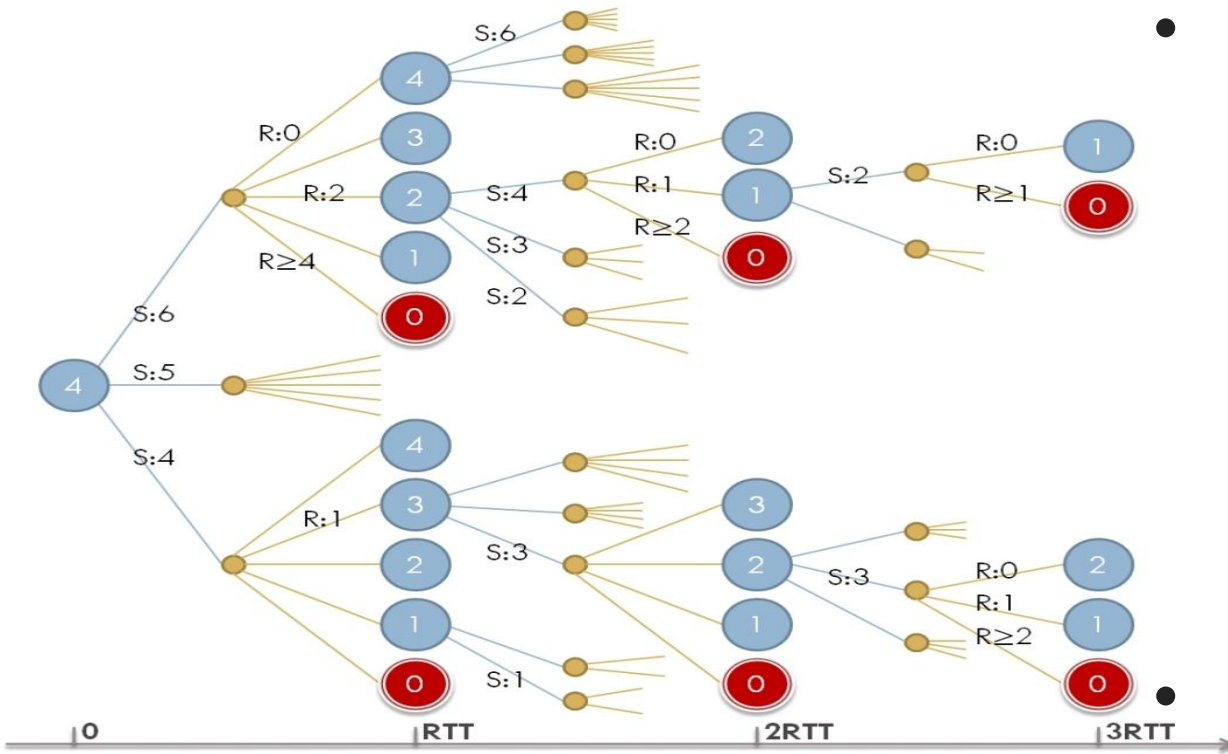








# Markov Decision Process (MDP) Formulation



- 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

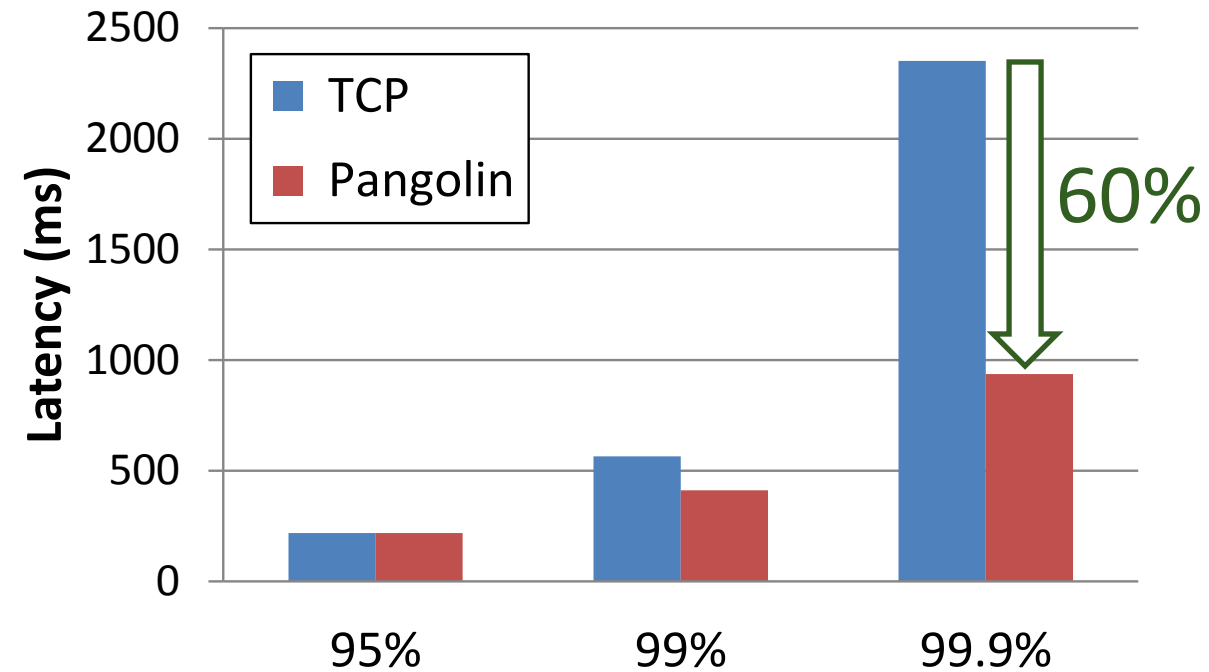
# Solving MDP

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

# Low Complexity Implementation

- Given packet loss rate, all optimal policies 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

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# BACKUP SLIDES

# 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