



Gamefest

MICROSOFT GAME TECHNOLOGY CONFERENCE 2 0 0 8

Networking, Traffic Jams, and Schrödinger's Cat

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XNA Framework Networking

- I spoke about networking at Gamefest 2007
- What the framework does for you
 - Finding and joining sessions
 - Synchronizing the list of players
 - Lobby transitions
 - Reliable UDP protocol
 - Voice 'just works'™

Confession

- My 2007 networking demo made some simplifying assumptions
 - Computer programs are deterministic
 - Bandwidth is infinite
 - Speed of light is fast enough to be irrelevant

The Inconvenient Truth

- Networked programs are only deterministic if you ignore time
- Bandwidth is far from infinite
- The speed of light is actually pretty slow!

The Five Stages of Networking

- Denial
- Anger
- Bargaining
- Depression
- Acceptance

DENIAL

The Ostrich Technique

- My game is small and simple
- 8 players $7 \times$
- 30 fps $30 \times$
- Each frame I send
 - Position : Vector3 $12 +$
 - Velocity : Vector3 $12 +$
 - IsFiring : bool 1 $)$
 $= 5.1 \text{ k}$

Packet Header Bandwidth

- IP header: 20 bytes
- UDP header: 8 bytes
- LIVE: 16 bytes
- XNA Framework: ~7 bytes
- = ~51 bytes

Game Data + Headers

- 8 players 7 x
 - 30 fps 30 x
 - Each frame I send (
 - Position : Vector3 12 +
 - Velocity : Vector3 12 +
 - IsFiring : bool 1 +
 - Packet header 51)
- = 15.6 k

Voice Bandwidth

- Voice data is ~500 bytes per second
- By default, all players can talk to everyone

Game Data + Headers + Voice

- 8 players 7 x
- 30 fps (30 x
- Each frame I send (
 - Position : Vector3 12 +
 - Velocity : Vector3 12 +
 - IsFiring : bool 1 +
 - Packet header 51) + 500)
- Voice data = 19 k
- ***Recommended limit is 8 kilobytes per second***

ANGER

WTF?

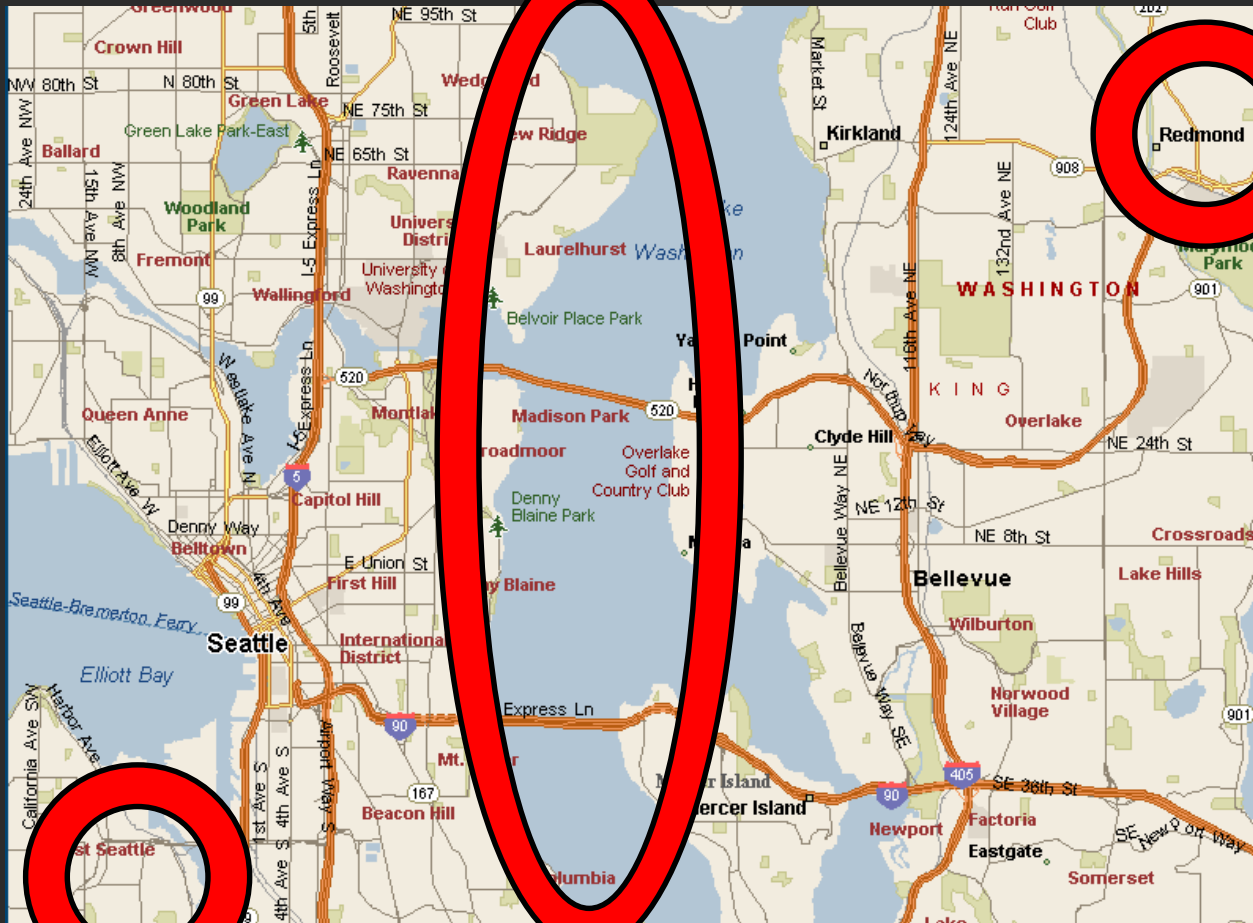
- Why so little bandwidth?
- My service provider claims way more
- Other apps report way more

Games Are Unforgiving

- The Internet is highly variable
- Service providers advertise their best case
- Web browsers care about the average
 - Occasional spikes are no problem
- Games are limited by the worst case
 - A 30 second glitch is enough to ruin gameplay

BARGAINING

My Morning Commute



Xbox LIVE Console Bandwidth

<i>% of consoles with this bandwidth or less</i>	<i>Downstream bandwidth (*)</i>	<i>Upstream bandwidth (*)</i>
0.1%	2.5	3
0.5%	5	5.5
1%	8	8
2%	9	10
5%	13	15
10%	18	22
30%	25	32
50%	42 (median)	44 (median)
70%	113	115
90%	648	693

Thanks to Bungie Studios for data collected during Halo 3 beta, 2007

*** Bandwidth in kilobytes per second**

Latency

- Speed of light = 186,282 miles per second
- Nothing can travel faster than this
- Seattle to L.A.
 - 960 miles = 5 milliseconds
- Seattle to England
 - 4,799 miles = 26 milliseconds
- Speed of light in fiber or copper slows to 60%
- Each router adds 5 to 50 ms
- DSL or cable modem adds 10 ms

Xbox LIVE Console Latency

<i>% of consoles with this latency or less</i>	<i>Round-trip latency between consoles (ms)</i>
10%	32
30%	57
50%	84 (median)
70%	130
90%	250
95%	320
97%	380
98%	430
99%	540
99.9%	770

Thanks to Bungie Studios for data collected during Halo 3 beta, 2007

DEPRESSION

Packet Loss

- `SendDataOptions.None`
 - Packets may never arrive, or may get jumbled
- `SendDataOptions.InOrder`
 - Cheap
- `SendDataOptions.Reliable`
 - Costs bandwidth
- `Reliable + InOrder`
 - Costs bandwidth and latency

ACCEPTANCE

Know Your Limits

- Bandwidth (kilobytes per second)
 - Typical: 12 to 250
 - Worst case: 8
- Latency (one-way)
 - Typical: 25 to 250 ms
 - Worst case: 270 ms
- Packet loss
 - Typical: 2%
 - Worst case: 10%

Live Within Your Means

- NetworkSession properties
 - BytesPerSecondSent
 - BytesPerSecondReceived
 - SimulatedLatency
 - SimulatedPacketLoss

Send Fewer Packets

- Trade bandwidth for latency
- Send data less often
 - Typically 10 to 20 times per second
- Prefer few big packets to many small ones
- Automatic packet merging
 - Multiple sends before `NetworkSession.Update`
 - Combines into a single wire packet

Send Smaller Packets

- Generalized compression algorithms are not much use
- Send smaller data types
 - int -> byte
 - Bitfields
 - Microsoft.Xna.Framework.Graphics.PackedVector
 - Matrix -> Quaternion + Vector3
 - Spawn position -> spawn point index
 - Avoid strings!

Send Less Voice Data

- LocalNetworkGamer.EnableSendVoice
- Only talk to players on your team
- Only talk to people near you in the world
- But avoid changing this too often

Know What Matters

- Some things matter a lot
 - Am I dead?
 - Who picked up the Pan Galactic Gargle Blaster?
 - Who won?
- Some things only matter a little bit
 - Where am I?
 - What direction am I moving?
- Some things don't matter at all
 - Which way did the dust particle bounce?

Distribute Your Workload

- PC games are usually client/server
 - Reduces cheating
 - Concentrates bandwidth load on one machine
- Xbox LIVE is more secure
- Peer-to-peer is a viable option
 - Avoids round-trip latency
 - Harder to maintain consistency

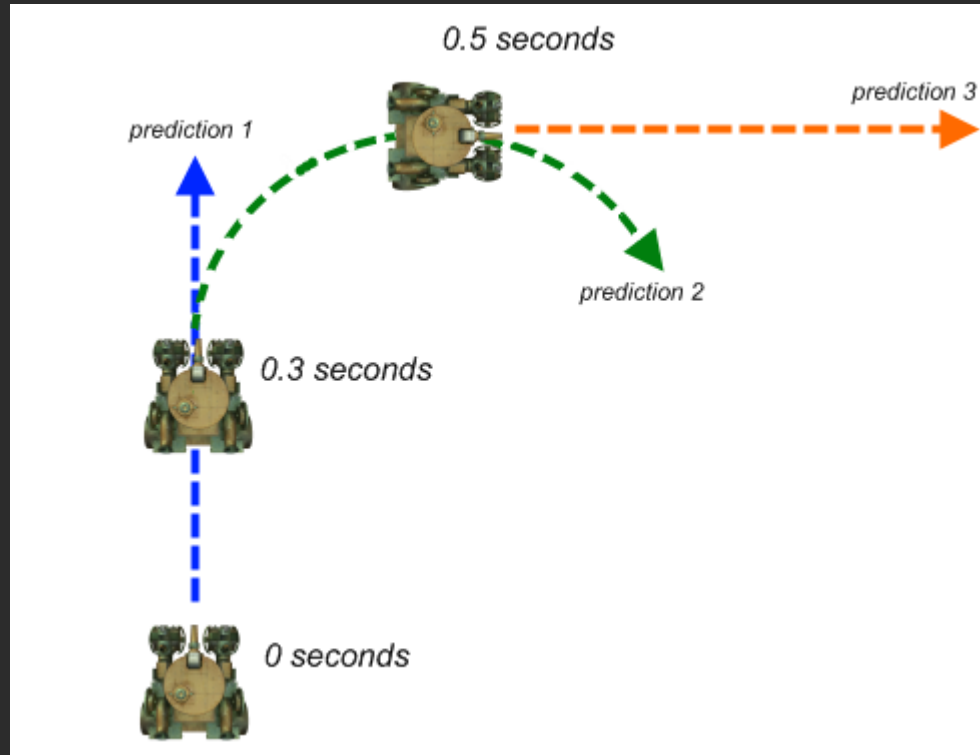
Hybrid Topologies

- Server makes important decisions
- Peers control most object movement
- Multiple specialized authorities
 - One machine controls powerups
 - Another tracks the score

Living With Latency

- Embrace quantum uncertainty
 - You can never know where an object is
 - Only where it used to be
 - ... and how fast it was moving
- The current state is a probability field
 - *Is the cat alive or dead?*
- Each player has their own parallel universe
- Our goal is to keep the universes similar
 - *No red pill*

Prediction



<http://creators.xna.com/en-us/sample/networkprediction>

Prediction Relativity

- Remember the parallel universes
- Send information relative to the recipient
- *‘Fired toward position (x, y, z)’*
 - What if players are in different places?
- *‘Shot at Shawn, missed 10° to the left’*
 - Robust even if player positions differ

Prediction Paradox

- Larger packets = less bandwidth
- Position + velocity + controller input
- More data makes prediction work better
- Allows lower packet send rate
- Fewer packet headers



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