Active Network Support Services Demonstration

Columbia University, University of California Berkeley, University of California Los Angeles, University of Utah

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Outline

- Introduction
- Description of the demo
- Nestor (Columbia)
- Panda (UCLA)
- Janos (University of Utah)
- Ninja (UC Berkeley)
- Conclusion

Introduction

- What are active network support services?
  - Node operating systems
  - Active network management
  - Middleware to make active networks more usable
  - General clustering services applied to active networks
- Generally, they assist core active network technologies (like EEs and active applications) in doing their jobs

Two Important Characteristics of These Services

1. Intended for use by many applications
   - Requiring high degree of generality
   - And interfaces usable by wide range of applications
2. Should interoperate naturally

The Demonstration

- Two goals
  1. Show the value of the support services
  2. Demonstrate interoperation
- Basic strategy
  - Show several support services working together
  - Adding value to an application using active networks

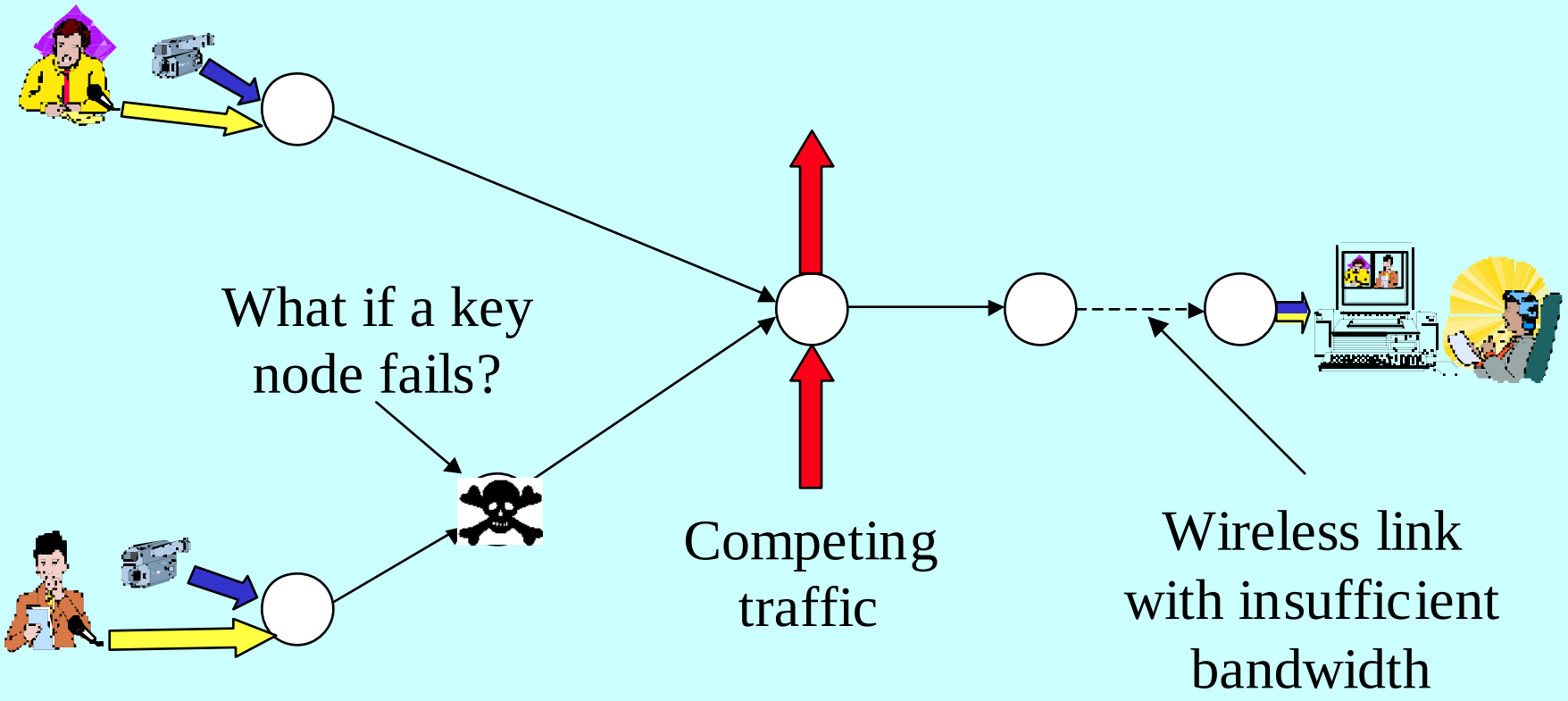
What Will We Be Showing?

- A videoconferencing application
- Built from basic video and audio streams
- Active services allow it to operate in difficult conditions
  - Poor network links
  - Competing traffic and applications
  - Failures
- Goal is to show obvious improvement

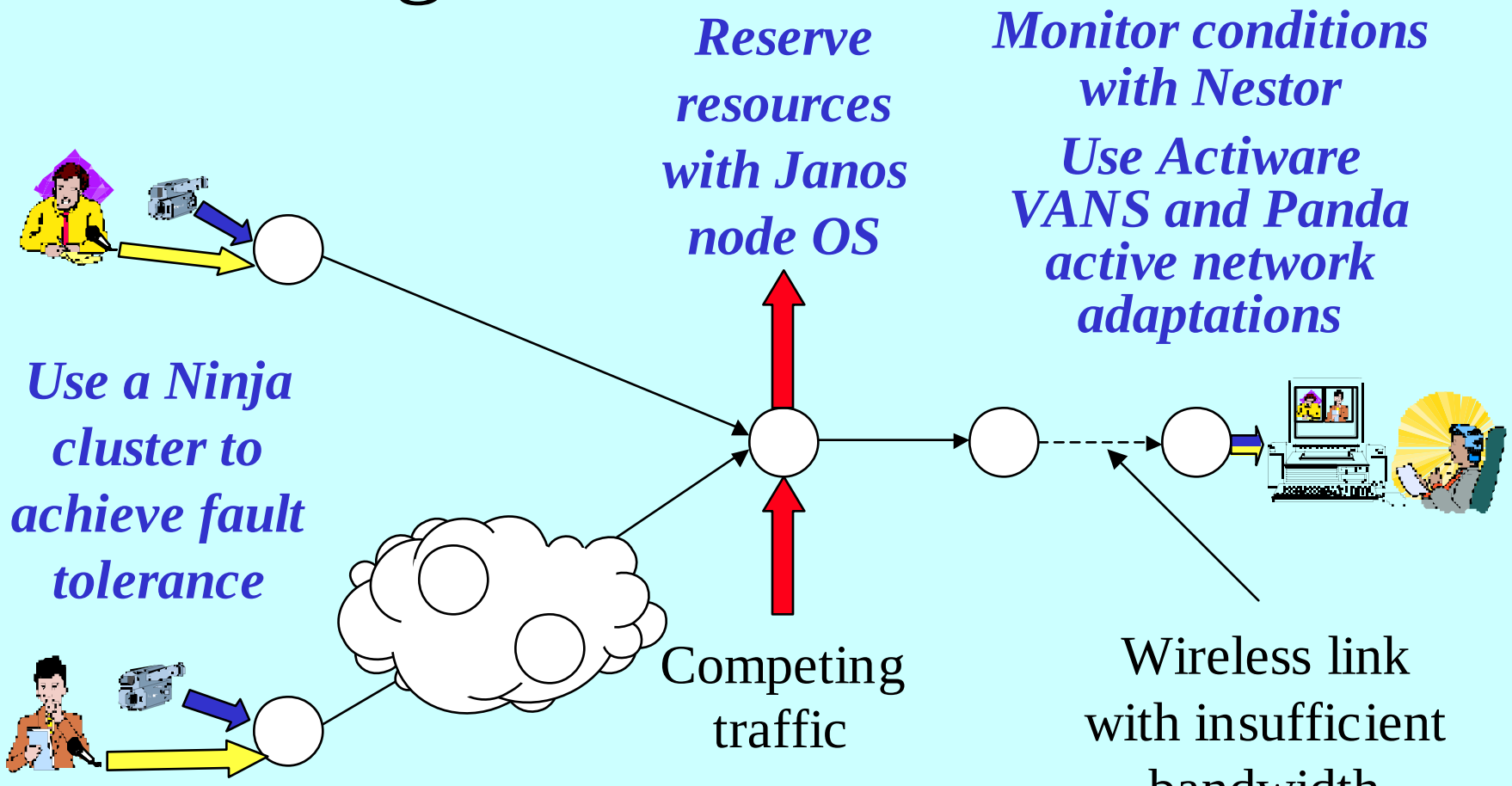
Some Details

- Two cameras streaming live video/audio
  - In WaveVideo wavelet encoding
  - Not directly using active networks
- Crossing a wireless link
  - Resulting in unacceptable video quality
- Facing competing traffic at one node
- Eventually, one of the service nodes fails

The Demo Situation



Solving the Demo's Problems



What Are Nestor and Actiware Doing?

- Nestor observes wireless link characteristics
  - Reports them to Panda, when requested
  - Also displays them in real time on a system management machine
- Actiware sets up virtual active network links for Panda over wireless link

What Is Panda Doing?

- Panda intercepts four non-active data streams and makes them active
- Sets up a (simple) plan for adaptation
  - Based on information from Nestor
- Runs adaptors at near end of wireless link
  - Adaptor that drops some wavelet levels
  - Adaptor that gives more bandwidth to speaker

What Is Janos Doing?

- Makes reservations for Panda flows on intermediate node
- In the face of competing:
  - CPU hogs
  - Network hogs
  - Memory hogs

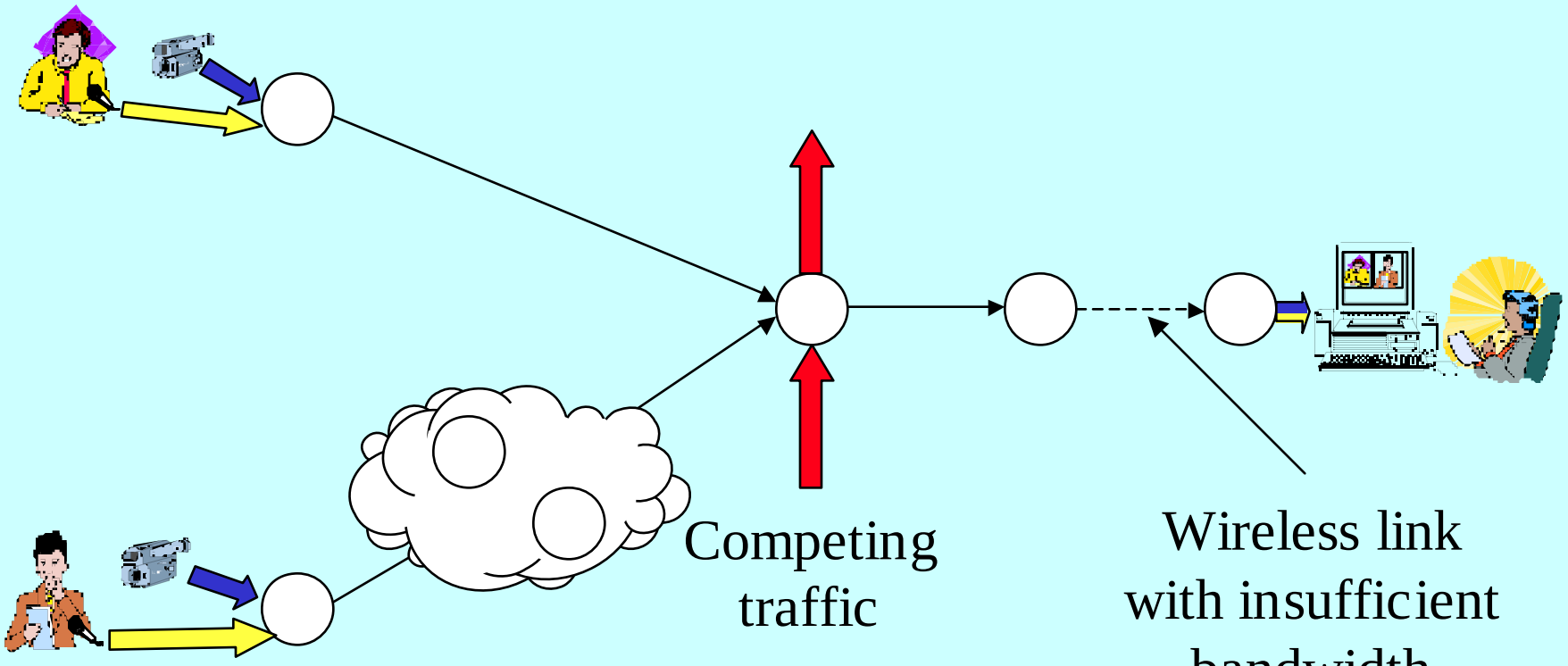
What Is Ninja Doing?

- Ninja runs Panda at one location in cluster mode
- When one cluster node running Panda fails, Ninja fails over to another node
  - In around one second

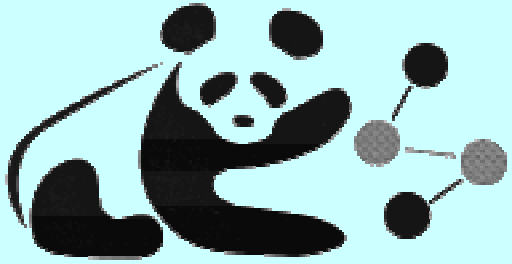
On With the Demo!

- Two live video/audio feeds are being sent through the network just described
- Note that the output sucks
- Let’s get started fixing it!

The Demo Setup



Actiware and Nestor



Panda

- Middleware to bring benefits of active networks to legacy programs and other AN-unaware programs
- Panda applies active network adaptations to selected non-active streams

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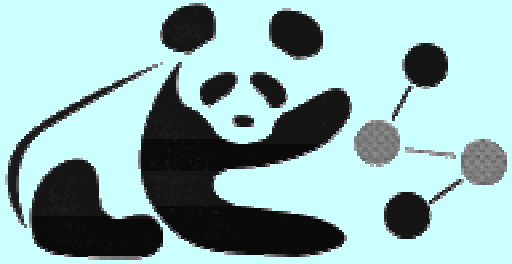

Adaptation of Unaware Applications

- Many existing applications don’t use active networks
- Many future applications won’t, either
- But many kinds of data streams are automatically recognizable
  - And adaptable using active networks

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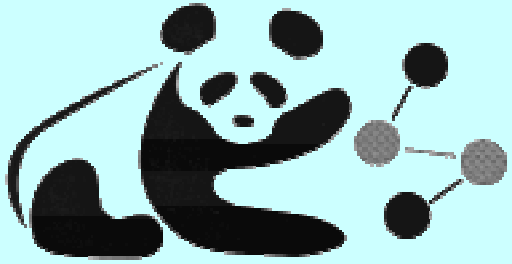

How Does Panda Help Unaware Applications?

- Intercept data streams at sending node
- Choose streams that Panda can handle
- Convert packets in stream to ANTS packets
- Deploy adaptors to do something helpful
- At destination, strip off ANTS stuff and deliver non-active packets

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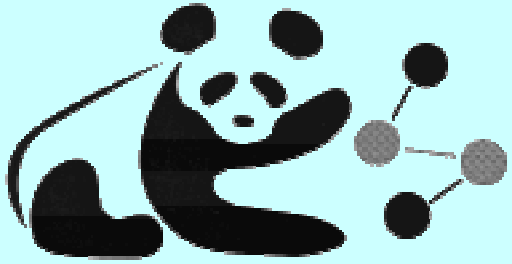

Adaptation Composition

- In complex networks, one adaptation at one place is often insufficient
- Combining multiple adaptations must be done carefully
- Requires planning to ensure adapter compatibility
  - And proper overall behavior

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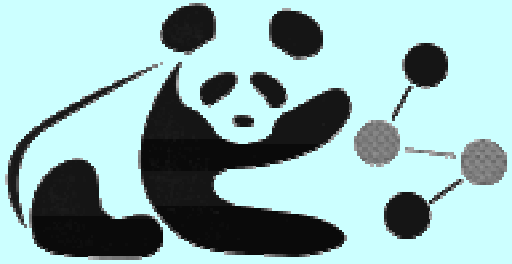

Panda Planning

- Two types of planning currently supported:
  - Planning at sending node
    - Sending node specifies which adapters and where
  - Hop-by-hop planning
    - Each node decides on local adapters
    - Using knowledge of previously deployed adapters
- Heuristics used in demo very primitive
- More sophisticated planning is partially implemented

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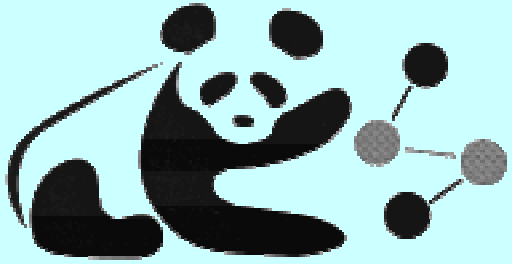

What Panda Does in the Demo

- Panda captures both video and both audio streams
- Converts them to ANTS active format
- Examines Nestor-supplied information about wireless link conditions
- Chooses plan to
  - filter wavelet encoding
  - use Actiware VANs to reserve bandwidth
  - give preferential treatment to speaker's streams
- Deploys and runs necessary adaptor
- Converts back to non-active form at destination

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Team 3: Demo 2000

Janos Project

University of Utah
Flux Research Group

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Java Active Network OS

- Java-oriented active network operating system
  - From AAs all the way down to the wires [JSAC 2001]
- Provides standard OS facilities
    - Separation
    - Resource control
    - Termination
- … but in a Java Virtual Machine

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Java Active Network OS

- Abstractions from operating systems [HotOS'99]
  - User/kernel boundary, process model
- Mechanisms from garbage collection:
  - Distributed GC, write barriers
- Key issue: controlled sharing
  - Packet buffers
- Based on KaffeOS [Back et al, OSDI 2000]
- Comprehensive resource control
  - Physical memory, CPU, outgoing network bandwidth

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Janos in the Demo

- Demonstration of Janos support for resource controls over Java code
  - CPU
  - Network bandwidth
  - Memory
- Demonstration of Java code in low-level networking

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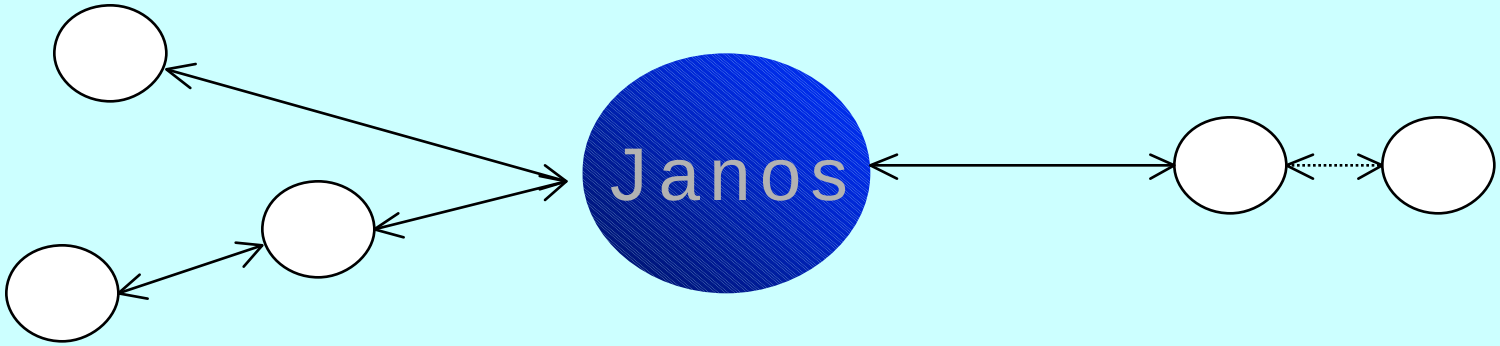
Janos in the Demo

- Janos node connects video source network and video display network



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Janos in the Demo

- IPFwd application forwards packets
- Hog applications waste resources
- All apps are written to Janos Java NodeOS API
- Each application runs in its own Java process
  - Separate GC, Heap, namespace, CPU, threads, etc.

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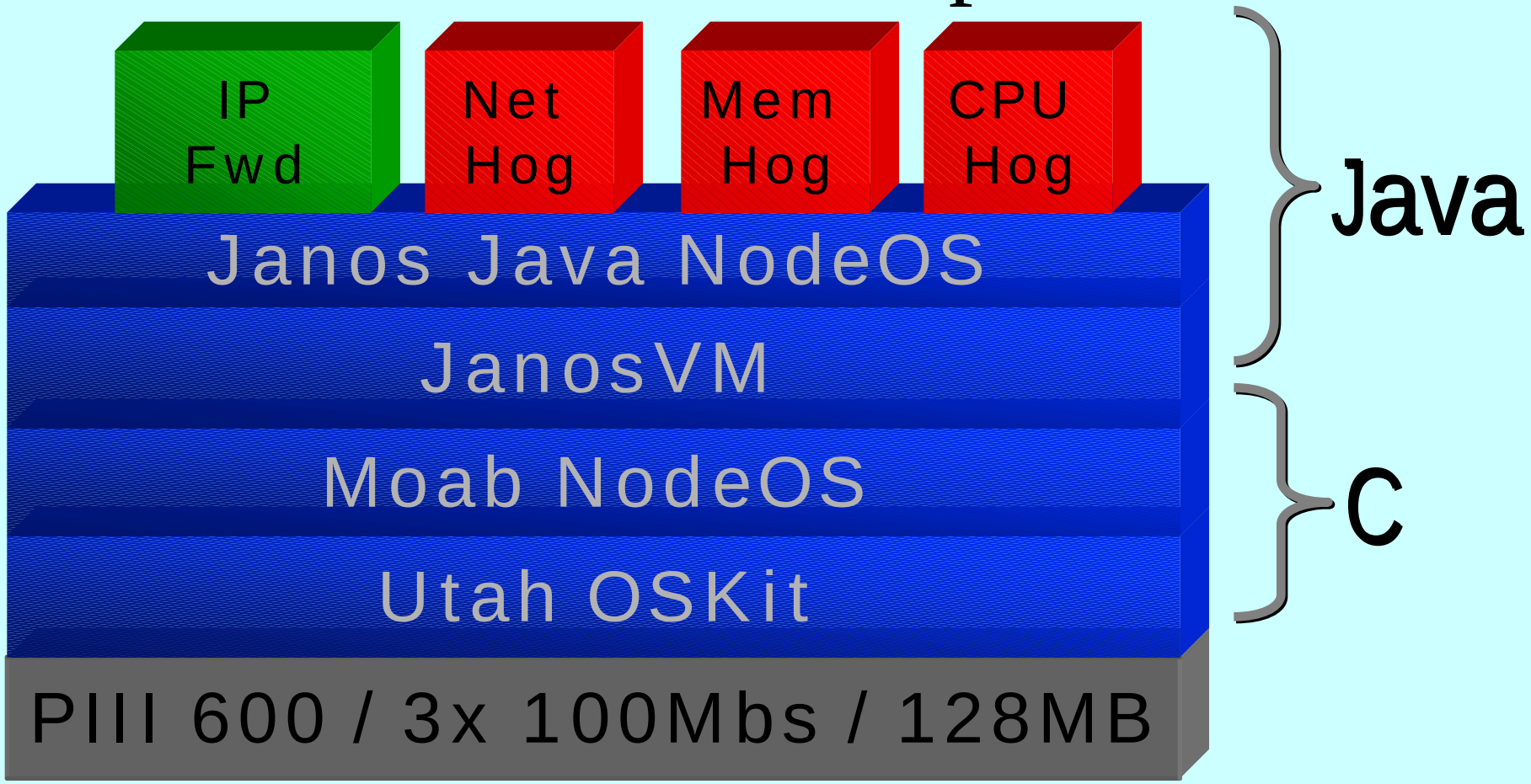
Janos Setup



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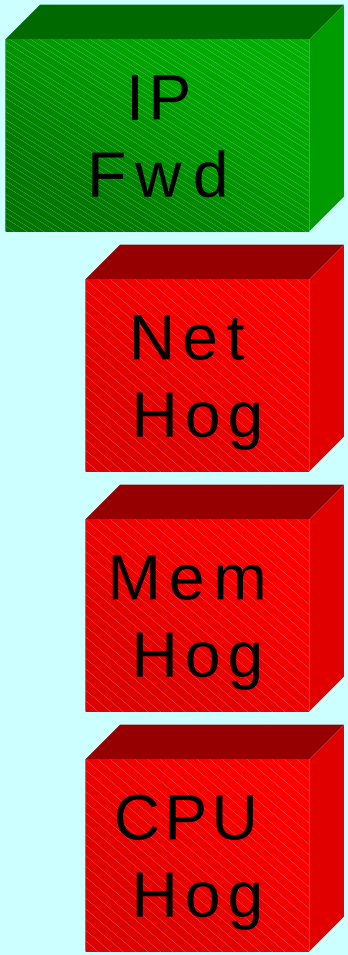
Janos Setup



Simple IP routing of two video streams to display network

Network bandwidth abuser

Consumes 90% of output link

Infinite memory waster

Java GC cleans up, restricted to 2MB

Endless CPU consumer

200 threads in infinite loops

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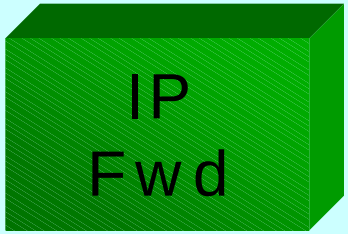

IP Forwarder

- Validates header checksum, decrements TTL, picks OutChan
- Written in Java:

```
if (bufHandle.computeChecksum(0, IPHeader.HEADER_LENGTH_NO_OPTIONS)!= 0)
        throw new Error("Bad checksum…");
if (!IPHeader.consumeTTL(bufHandle, 0))
        throw new Error("No time to live…");
routeEntry = this.lookupRoute(this.iface,
        IPHeader.getDestination(bufHandle, payloadOffset));
if ((outChan = routeEntry.getChannel()) != null)
        oc.send(bufHandle);
```

- Zero-copy buffer access

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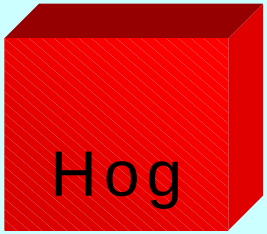

(Net|CPU|Mem) Hog

- Runs in own Janos domain
- Efficiently wastes just one resource
  - Net hog gets significant CPU allocation
- Each written in Java

Stats & Control

- Talks to GUI on separate NIC

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Performance

- More than enough for the demo
  - 500 pps, ~500 bytes per packet
- IP Forwarder handles almost 18Kpps
  - About 40% of the C version
- Ping across forwarder in less than 1ms

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Demonstration

- Janos manages CPU, memory, network usage of each domain.
- Parameters are setup such that
  - Forwarder flow gets more than enough
  - “X” hog gets a small share of “X”
- “Disabled” scheduler is simple round-robin over quantum (time slice or “packet send”)
- Memory scheduler cannot be disabled
  - Cannot revoke allocated pages

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Future Work

- Performance
  - Interrupt -> Polling model for rx
  - JanosVM optimizations
  - (JIT & GC optimizations, etc.)
- Build applications to our model
  - Validate the sharing/separation
- Improve resource schedulers
  - Include latency requirements

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Summary

- Janos provides resource guarantees to active network code
- Janos supports Java code for systems
  - Zero-copy buffer access
  - Full NodeOS API available (except Mem)
- Janos provides OS process model for Java applications

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Available

http://www.cs.utah.edu/flux/janos/

- NodeOS in C: Moab
  - OSKit, Linux, FreeBSD, Solaris
- NodeOS in Java:
  - Bindings for: Moab, JDK, (soon) AMP
- JanosVM
  - Available soon
- ANTS
  - ANTSR available now
  - ANTS 2.0 available soon

Janos and KaffeOS papers available today and on web

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Ninja

What Has This Demo Shown?

- Benefits of active network technologies
  - Specifically, of AN service technologies
  - Obvious benefit to a realistic service
- Ability of various active network services to interoperate beneficially
- Application of active networks to non-active applications

Demo Lessons

- Network configuration is a pain
- Wireless is a pain
  - Suggesting it's actually a good place to look for active network opportunities
- Increasing maturity of components has actually made them useful
- Demo devils are in the details

Why Didn’t We Get Better Frame Rates?

- Multiple passes up and down through ANTS and kernels
- Wireless limitations
- Need better adaptations
  - E.g., packet aggregation
- Java runtime overheads

Credits

- Who actually did the work?
  - Kevin Eustice (UCLA)
  - Ramakrishna Gummadi (UCB)
  - Patrick Tullman (Utah)
  - Alexander Konstantinou and Gong Su (Columbia)