

Carnegie Mellon University

JackTrip

A efficient solution for remote audio transmission

Dalong Cheng <dalongc@andrew.cmu.edu>

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Presentation Outline

1. Keyword, Concept Review
2. Challenges for Audio Transmission
3. JackTrip's Solution
 - ▶ Motivation
 - ▶ Architecture
 - ▶ Buffer Design
 - ▶ Redundancy Design
4. A JackTrip's Extension
 - ▶ Motivation
 - ▶ Evaluation Metrics
 - ▶ Design
 - ▶ Implementation

UDP

- **Single socket to receive messages**
- **No guarantee of delivery**
- **Not necessarily in-order delivery**
- **Datagram – independent packets**
- **Must address each packet**

Postal Mail

- **Single mailbox to receive letters**
- **Unreliable 😊**
- **Not necessarily in-order delivery**
- **Letters sent independently**
- **Must address each reply**

Example UDP applications
Multimedia, voice over IP

TCP

- **Reliable – guarantee delivery**
- **Byte stream – in-order delivery**
- **Connection-oriented – single socket per connection**
- **Setup connection followed by data transfer**

Telephone Call

- **Guaranteed delivery**
- **In-order delivery**
- **Connection-oriented**
- **Setup connection followed by conversation**

Example TCP applications

Web, Email, Telnet

LAN & WAN

Review

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Summary

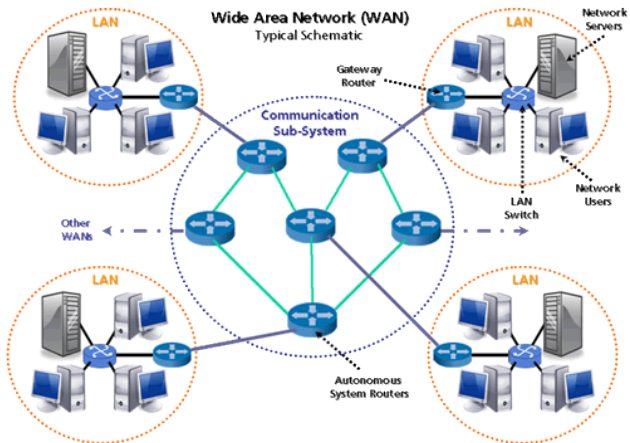


Figure: LAN & WAN

Process & Thread

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Summary

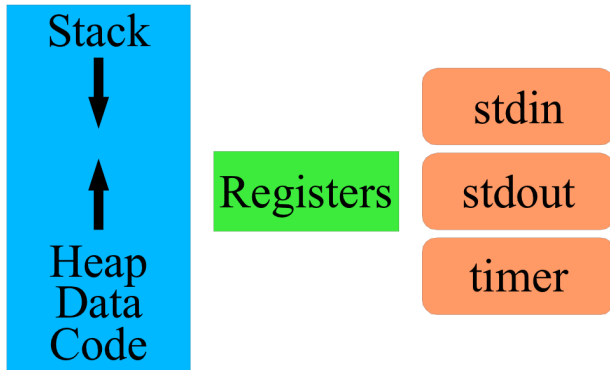


Figure: Process Model

Process & Thread

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Summary

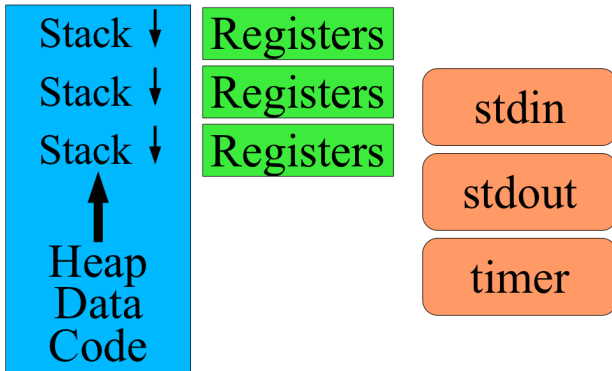


Figure: Process with Multi-thread

Scheduling & Block & Non-Block

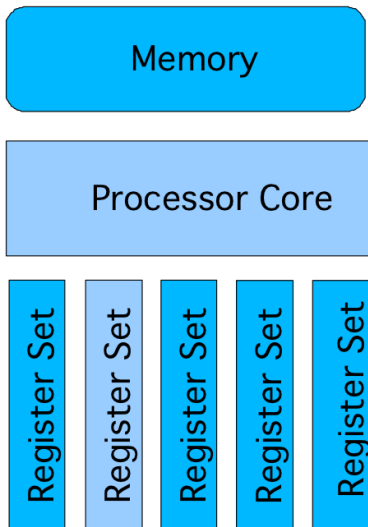
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Summary



Classic Multi-Thread Program Model

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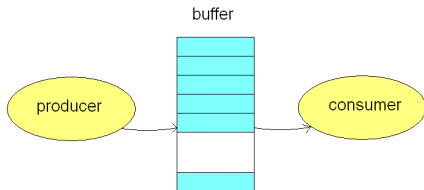


Figure: Single-Producer & Consumer Model

- ▶ More than one consumer thread (Thread Pool)
- ▶ What if more than one producer and consumer

Distributed Flavor

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Summary

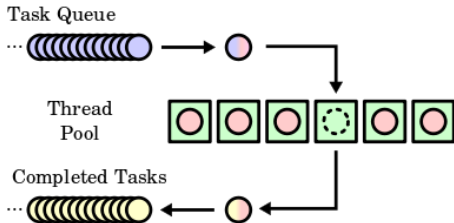


Figure: Architecture of HCMP

- ▶ A single node to receive all request
- ▶ Add a “dispatcher” to assign work

“Universal” Distributed System Design Principle

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Summary

1. Add another layer of indirection & abstraction
2. Add cache & buffer

Problem Definition

1. WAN, Bi-directional, Audio, Transmission
2. Similar Problems (Not Same!)
 - ▶ LAN Area Studio System
 - ▶ Uni-directional WAN Streaming

Objective

1. Latency Critical (25ms is upper bound!)
2. Maximize Audio Quality (Tradeoff)

Possible Solution

1. ~~Compressed Audio~~
2. ~~One-way recording techniques~~

Audio Latency

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Summary

1. Acoustic Delay
2. Analogue to Digital, Digital to Analogue Delay
3. Transmission Delay
4. Settings Chosen for Audio Quality
(Etc. Sample Rate, Buffer, Packet Size)
 - ▶ 96kHz Sample Rate, Audio Buffer 64 samples, deliver
 $64/96000 * 1000 = 0.67\text{ms}$

Basic Approach

- ▶ Transfer Uncompressed Audio
(require large bandwidth)
- ▶ Use UDP instead of TCP
 - ▶ TCP, Retransmission, Fix-Order, Ack-Scheme
 - ▶ Have to deal with UDP lost packet :(
- ▶ Ring buffer

Architecture - Sender

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Summary

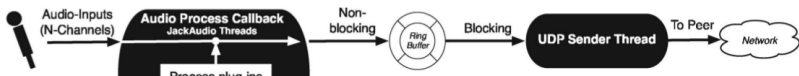


Figure: Sender

- ▶ Block if empty
- ▶ Ring buffer for share

Architecture - Receiver

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Summary

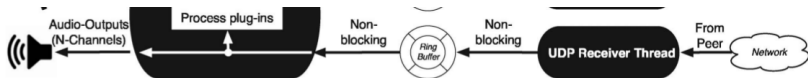


Figure: Receiver

- ▶ Never block
- ▶ Ring buffer for share

Architecture - Whole Picture

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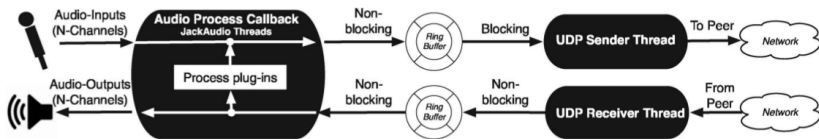


Fig. 1. JackTrip architecture overview.

Figure: Architecture

Ring Buffer Analysis

Review

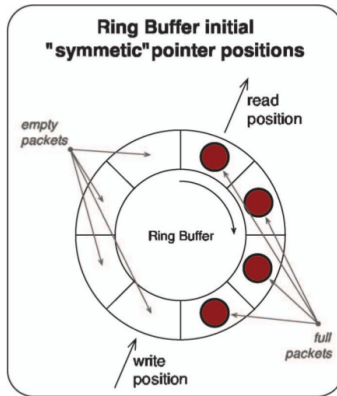
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Summary

- ▶ Ring buffer is to Inter-thread Communication
- ▶ Initialization
- ▶ What is ideal situation, What is two possible consequence



Consequence 1 - Underflow

- ▶ $V_{read} > V_{write}$
- ▶ Reason: packet lost or network jitter
- ▶ Solution: send silent or last received packet

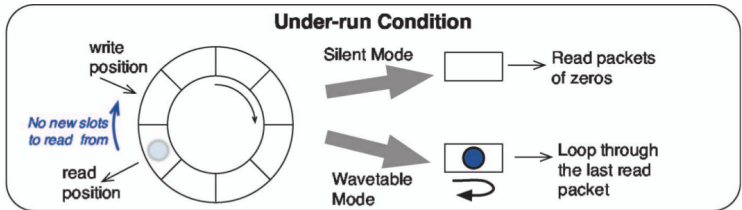


Figure: Ring Buffer Underflow

Consequence 2 - Overflow

- ▶ $V_{write} > V_{read}$
- ▶ Reason: clock drift, peer's clock faster than local clock
- ▶ Solution: reset read position (drop samples)

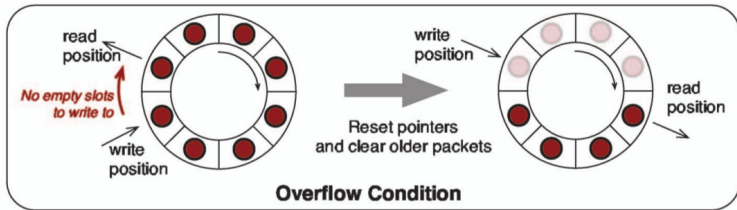


Figure: Ring Buffer Overflow

UDP's Price - Redundancy

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Summary

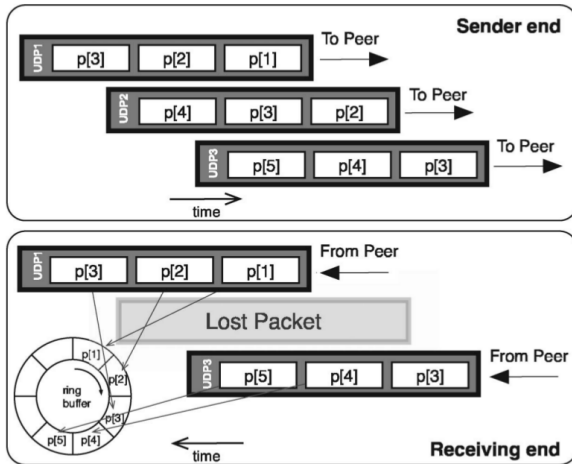


Figure: Redundancy

A Interesting Extension

Think of Such Scenario

- ▶ You have a musician friend
- ▶ You build a tool for him to use
- ▶ He need to tune parameters everytime using the tool
- ▶ He don't understand those parameters

Evaluation Metric

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Summary

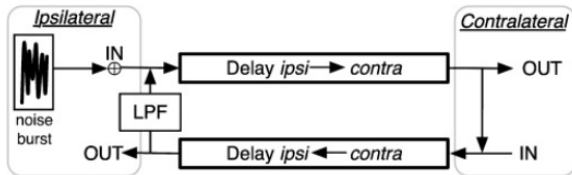


Figure: Karplus - Strong string model

- ▶ Pinging the network acoustically
- ▶ Ipsilateral be server side
- ▶ Contralateral be client side

Server Architecture 1

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Summary

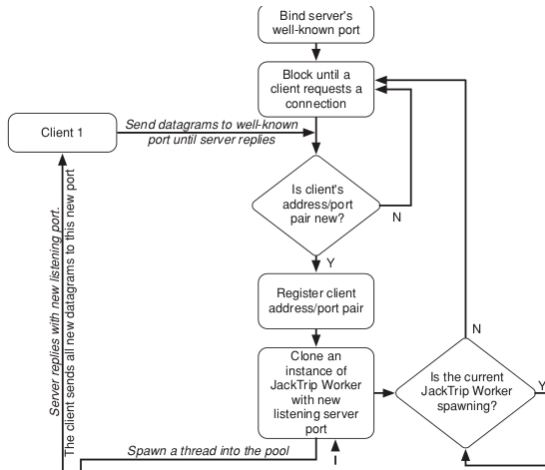


Figure: Server Architecture1

Server Architecture 2

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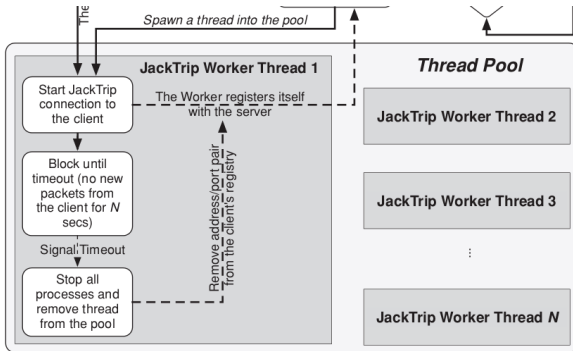


Figure: Server Architecture2

Summary

- ▶ Multi-thread model in audio
- ▶ Ring buffer
- ▶ Use ear to facilitate tuning parameters