# Reduced Switching Delay for Networked Music Performance

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## Motivation

- **NMP:** Networked Music Performance  
  - Ultra-low delay variant of conferencing  
  - End-to-end delays of 25 rather than 150 ms  
- **The MusiNet project**  
  - Ultra-low delay audio and video coding  
  - Optimized media capture and packetization  
  - What else can we optimize?  
- **Multipoint Conferencing Unit (MCU)**  
  - Receives data streams from each participant  
  - Mixes all data streams together  
  - Relays the resulting data stream to each participant

## The MusiNet MCU

- NMP is not the same as conferencing  
  - Participants prefer to do their own mixing  
  - The MCU should only relay data streams  
  - Each participant indicates what it wants to receive  
  - The MCU maintains a stream routing table  
  - Media packets are replicated and forwarded  
  - A relaying MCU costs 20 ms of delay  
  - Too much context switching  
  - Too much packet copying  
  - Too many packet exchanges

### MCU with NetFPGA

- **NetFPGA:** four network interfaces plus an FPGA  
  - Arbitrary processing at the hardware level  
  - Split processing between MCU and NetFPGA  
  - The MCU receives only signaling packets  
  - The routing table resides at the NetFPGA  
  - Media packets handled by the NetFPGA  
  - Virtually no context switching  
  - Packet copying can be eliminated  
  - No CPU load for packet routing

### MCU with Click

- **The Click modular software router**  
  - Consists of a set of routing modules  
  - Operates at either user or kernel level  
  - The MCU receives only signaling packets  
  - The routing table resides within Click  
  - Media packets handled by Click  
  - Test at user level, operate at kernel level  
  - Virtually no context switching  
  - May be able to eliminate packet copying

### MCU with netmap

- **The netmap framework for packet handling**  
  - Applications handle packets in kernel memory  
  - No system calls needed to manipulate packets  
  - The entire MCU resides at the application level  
  - Both signaling and media packets handled by MCU  
  - Can use any programming language  
  - Packet copying can be eliminated  
  - Context switching may be reduced

## Conclusion and Future Work

- Three ways to reduce MCU delays  
  - Take advantage of hardware (NetFPGA)  
  - Move processing to kernel level (Click)  
  - Manipulate packets in the kernel (netmap)  
- Current work  
  - User level Click implementation started  
  - Netmap implementation started  
- Future work  
  - Kernel level Click implementation  
  - NetFPGA implementation if needed