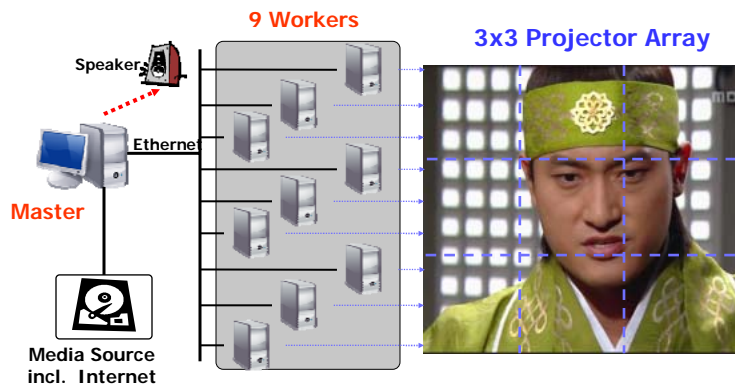


Selection and Adjustment of Timing Parameters in Applications Structured as TMO Networks

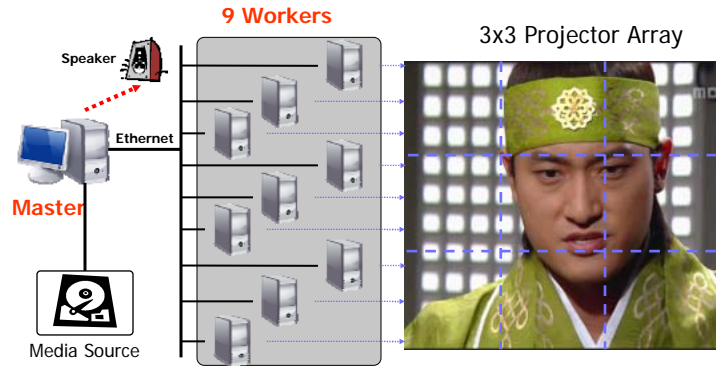
Example 2. Tiled Display

Tiled Display Application Scenario



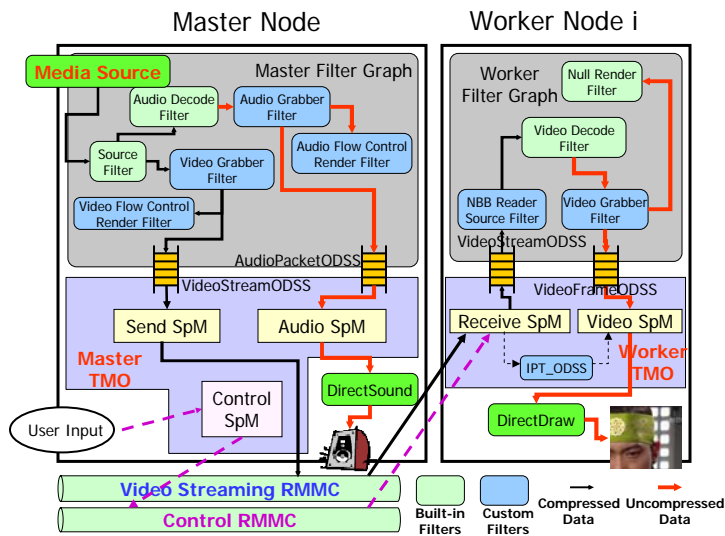
- **One master node**
 - Retrieves multimedia data streams, broadcasts a video stream to all workers, and commands video playback on worker nodes
 - Audio stream playback
- **Multiple worker nodes**
 - Receive & decode video stream and display parts corresponding to worker IDs

TMO-based Tiled Display Architecture



- High-level scheduling of video rendering and video packet multicasts is also important

System Components



Master Node

- **Master filter graph**
 - Source filter: Reads media source and splits it into audio stream and video stream
 - Audio decode filter: Decodes audio stream
 - Audio/video grabber filter: Grabs audio/video packet from the filter graph
 - Audio/video flow control render filter: Controls audio/video grabbing rate
- **Master TMO**
 - AudioPacket / VideoStream ODSS: hold uncompressed audio packets and compressed video packets, respectively
 - **Send SpM**: Reads from VideoStream ODSS and broadcasts to all workers
 - **Audio Play SpM**: Reads from AudioPacket ODSS and plays back
 - **Control SpM**: Sends control signal

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Worker Node

- **Worker filter graph**
 - NBB reader source filter: Reads video stream from NBB
 - Video decode filter: Decodes video frame
 - Video grabber filter: Grabs video frames from filter graph
 - Null render filter: A fake render filter
- **Worker TMO**
 - VideoStream / VideoFrame ODSS: Holds compressed and uncompressed video frame, respectively
 - **Receive SpM**: Receives video frames from master and put them to VideoStream ODSS
 - **Video Play SpM**: Reads from VideoFrame ODSS and plays back

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System Components – Communication Channel

- **Video streaming RMMC**
 - RMMC for video streaming
- **Control RMMC**
 - RMMC for control signal

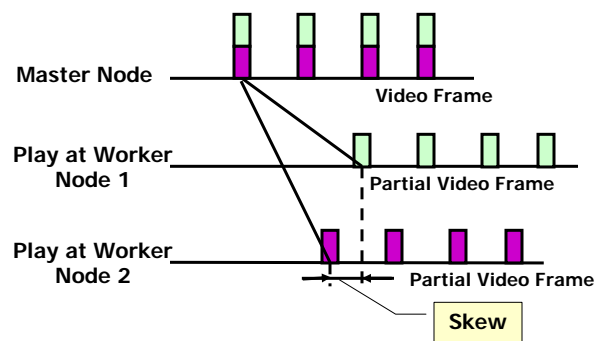
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Synchronous Playback

- **Two requirements**
 - Video stream play starts at the **same time** in all worker nodes.
 - Video frames are played at the **same rate** in all worker nodes.
- **Asynchronous initial plays cause a skew among different worker nodes**



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Initial Play Time (IPT)

- User's input of a "PLAY" command to the master node
 - => Received by **Control SpM**, which in turn sends a "Play" message to all worker nodes at **T** through a Control RMMC.
 - => **Control SpM** starts the **master filter graph** which fetches multimedia data from the media source
 - => **Send SpM** periodically broadcasts video frames to worker nodes through the Video Streaming RMMC.

- **Receive SpM** in a worker node receives the "Play" message
 - => It starts the **worker filter graph** which receives video frames, decodes, and buffers them
 - => **Video SpM** periodically plays the frames

The "Play" message contains an **Initial Play Time (IPT)**, where

$$IPT = T + D$$

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Initial Play Time (IPT)

- The "Play" message contains an **Initial Play Time (IPT)**. Basically,

$$IPT = T + D$$

where **D** is the target delay in video playback start.

- One implementation:

$$IPT = EST + \{\text{ceiling}[(T + D) / P]\} * P ,$$

Where **P** is the period of Video SpM.

- At the beginning of each iteration, Video SpM checks if IPT is already past (or will arrive shortly within the start-time window -> This case is highly unlikely).

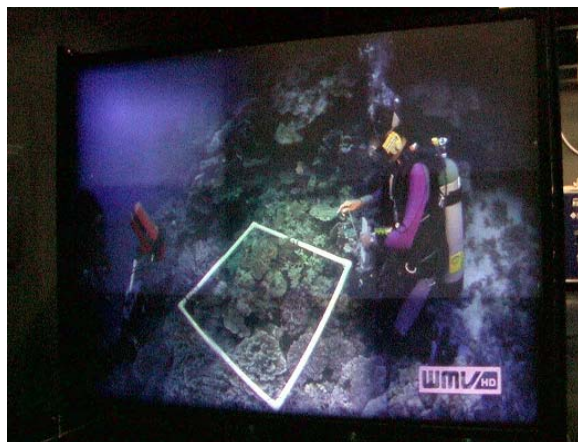
If so, the first frame-fragment will be played immediately.

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Snapshot of TMO-based Tiled Display Application on a Projector Array

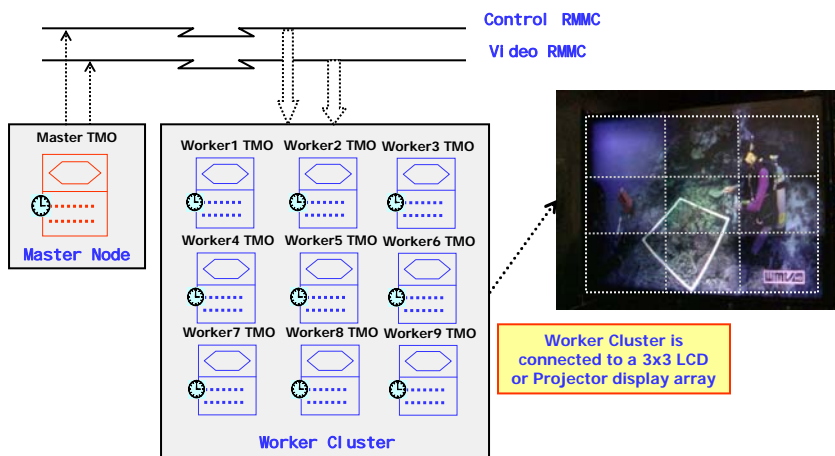


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Tiled Display TMO Network



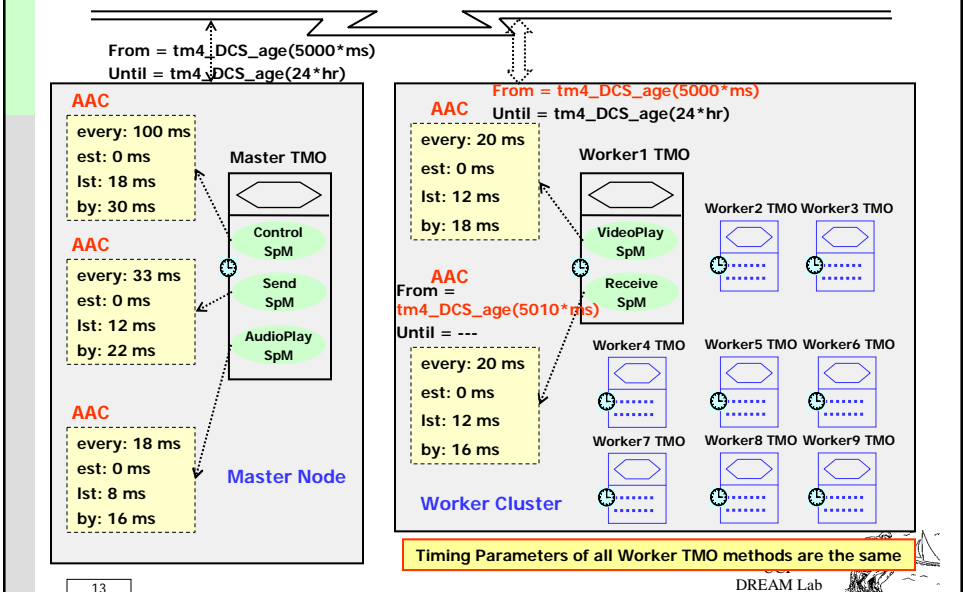
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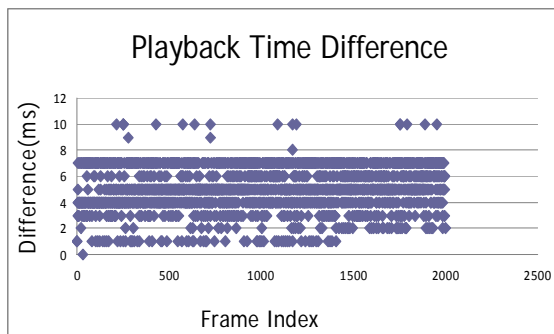


Timing Parameters in Tiled Display

RMMCs



Performance Measurement

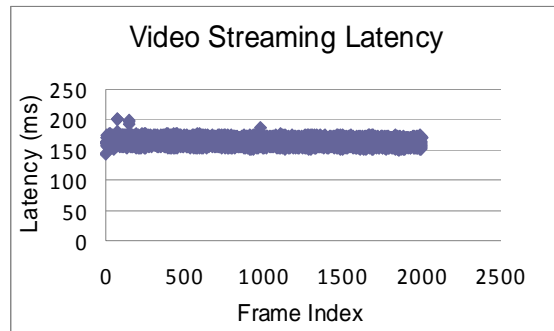


Playback Time Difference:

Difference between the latest and the earliest playback times for each frame across all worker nodes.



Performance Measurement (cont.)



Video Streaming Latency:

The latency from the time when a video frame is first extracted from the media source by the master node to the time when it is played back by a worker node.

