CS 414 – Multimedia Systems Design

Lecture 36 – Synchronization (Part 3)

Klara Nahrstedt

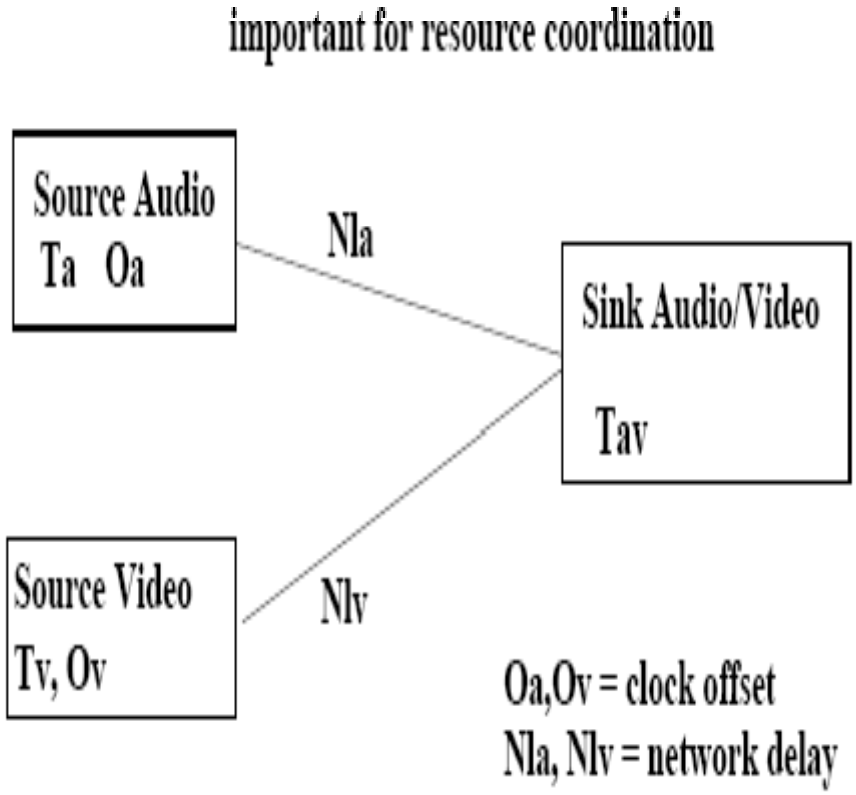
Spring 2008

Outline

- Clock Synchronization
- Synchronization Specification Methods
  - Requirements
  - Interval-based Specification
  - Axes-based Specification
  - Control Flow-based Specification
    - hierarchical approach
    - Timed Petri nets
  - Event-based Specification

Clock Synchronization

- Sync accuracy depends or clocks at source and sink nodes
  - $T_a = T_{av} – Nl_a – O_a$
  - $T_v = T_{av} – Nl_v – O_v$
- End-to-end delay
  - $Nl_a = EED_a = T_{av}-T_a-O_a$
  - $Nl_v=EED_v = T_{av}-T_v-O_v$
  - $EED_a = (T_{a1}-T_{a2})/2$
- NTP (Network Time Protocol)

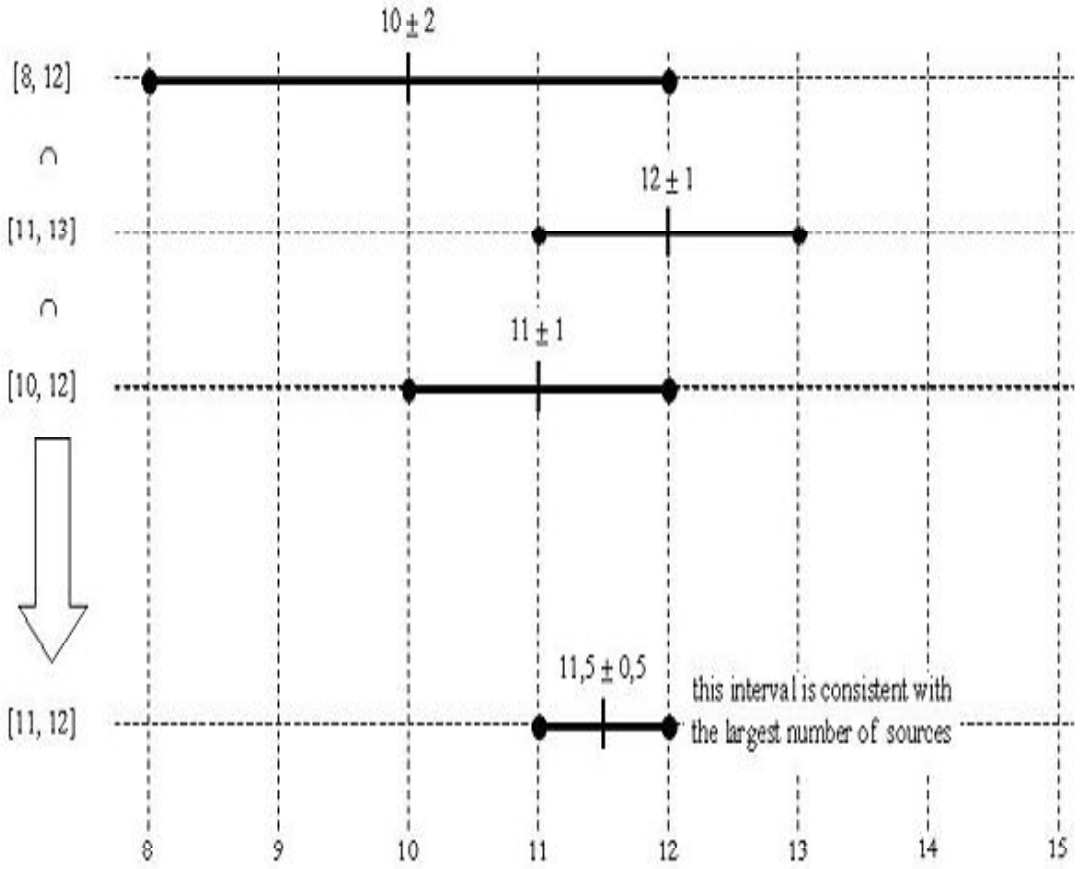


Network Time Protocol

- Protocol to sync clocks of computer systems over packet-switched, variable – latency data networks
  - Uses UDP port 123
  - Designed to resist effects of variable latency (jitter buffer)
  - Designed in 1985 by Dave Mills at U. Delaware
  - Can achieve accuracy of 200 µsec
  - Based on Marzullo Algorithm

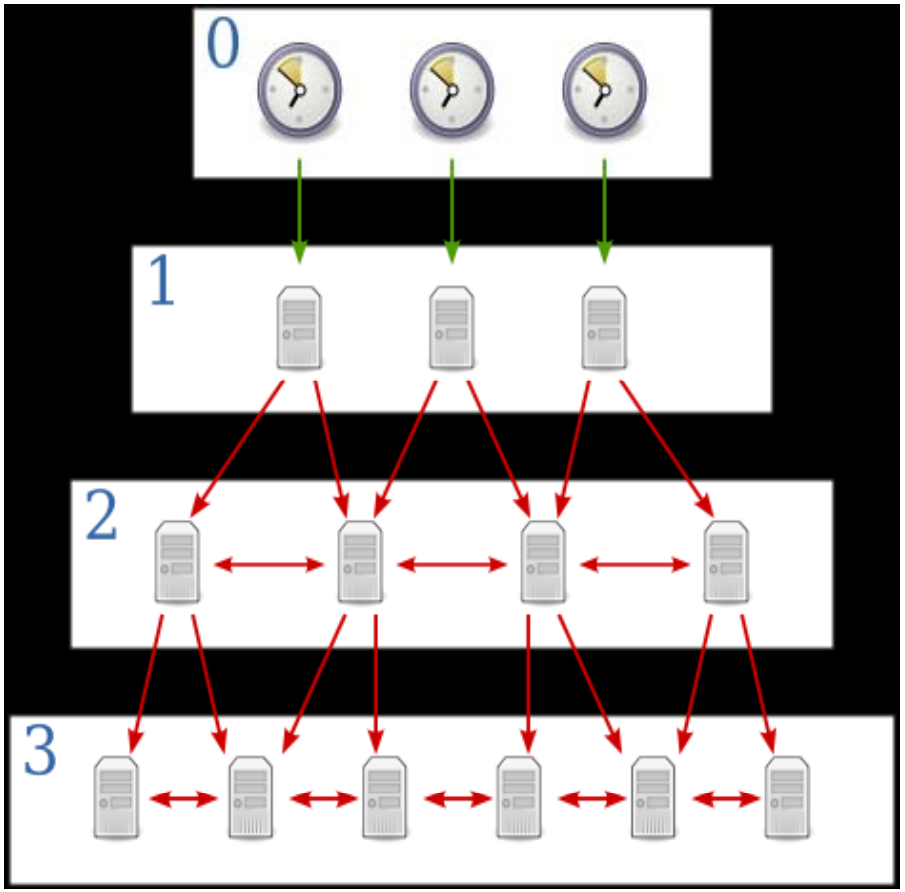
Marzullo's algorithm (1984)

- Agreement protocol for estimating accurate time from a number of noisy time sources
- If we have estimates
- 10 ± 2, 12 ± 1, 11 ± 1, then interval intersection is 11.5 ± 0.5
- If some intervals don't intersect, consider intersection of majority of intervals



Clock strata

- NTP uses hierarchical system of “clock strata”
- Stratum levels define distance from reference clock and exist to prevent cycles in hierarchy
  - Stratum 0
    - devices are atomic clocks, GPS clocks, radio clocks
  - Stratum1
    - computers attached to stratum0 devices
    - Act as servers for timing requests from Stratum 2 servers via NTP
  - Stratum2
    - (similar to Stratum1. but they also have peering relation to other stratum2 servers



Sync Specification Methods - Requirements

- Object consistency and maintenance of sync specifications
  - Media objects should be kept as one LDU in spec
- Temporal relations must be specify-able
- Easy Description of Sync Relations
- Definition of QoS requirements
- Integration of time-dependent and independent media
- Hierarchical levels of synchronization

Models

- Interval
- Timeline
- Hierarchical
- Reference points
- Petri net
- Event-based

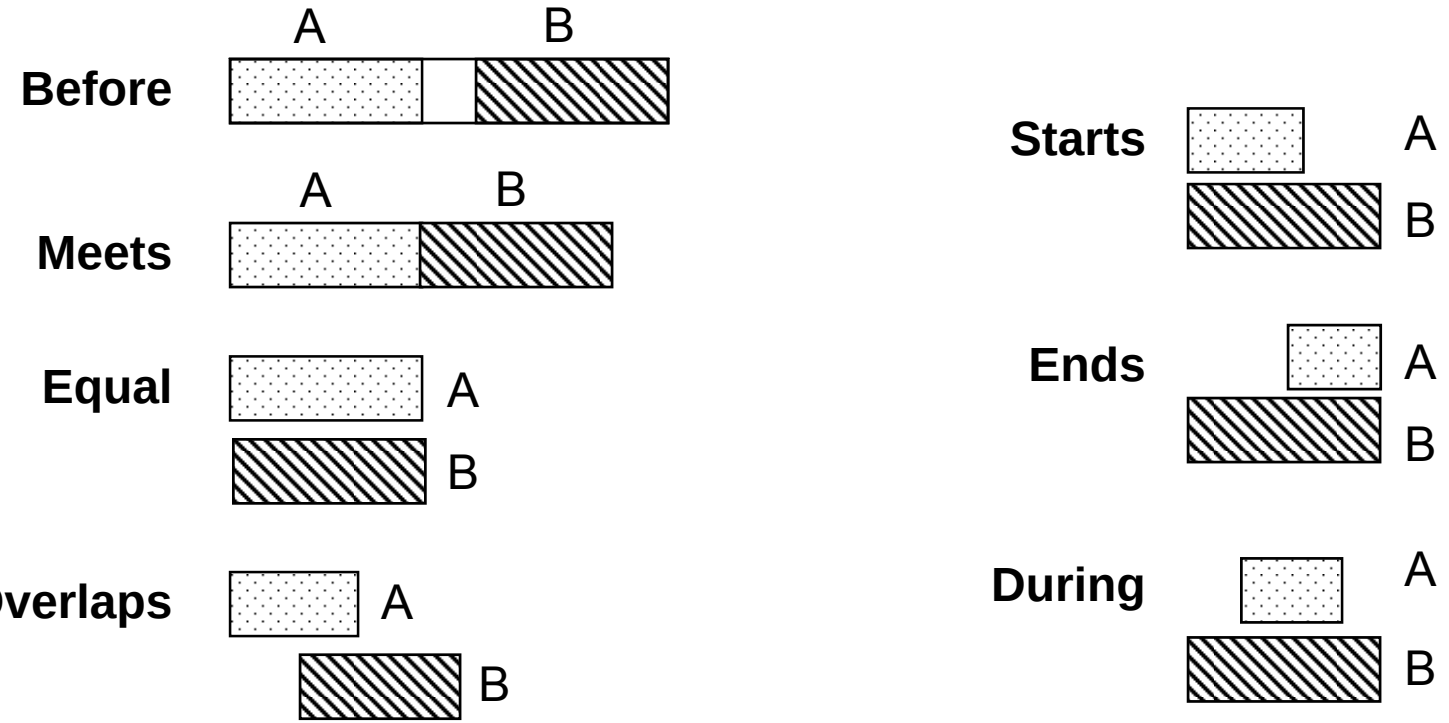
- Common threads
  - provide language to express relationships
  - runtime system to monitor relationships
  - policies to enforce relationships

Interval-based Specification (1)

- Presentation duration of an object is specified as interval
- Types of temporal relations:
  - A before B, A overlaps B, A starts B, A equals B, A meets B, A finishes B, A during B
- Enhanced interval-based model includes 29 interval relations, 10 operators handle temporal relations (e.g., before(δ1),…)

Interval Model (2)

- 13 relationships between two intervals



Example (3)

Audio1 while(0,0) Video

Audio1 before(0)
RecordedInteraction

RecordedInteraction before(0) P1

P1 before(0) P2

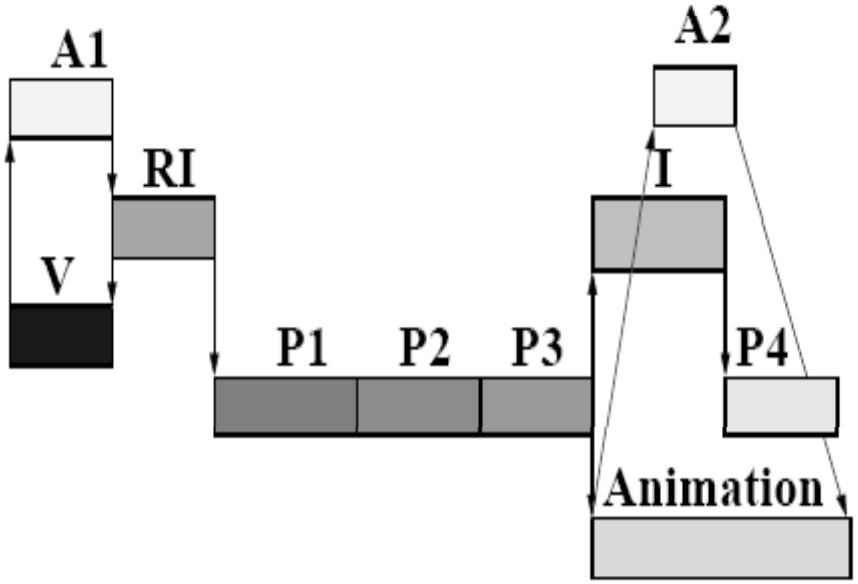
P2 before(0) P3

P3 before(0) Interaction

P3 before(0) Animation

Animation while(2,5) Audio2

Interaction before(0) P4



Interval-based Specification (4)

- Advantages:
  - Easy to handle open LDUs (i.e., user interactions)
  - Possible to specify additional non-deterministic temporal relations by defining intervals for durations and delays
  - Flexible model that allows specification of presentations with many run-time presentation variations

Interval-based Specification (5)

- Disadvantages:
  - Does not include skew spec
  - Does not allow specification of temporal relations directly between sub-units of objects
  - Flexible spec leads to inconsistencies
    - Example:

      A NOT in parallel with B

      A while(2,3) I

      I before(0) B

Timeline Axis-based Specification

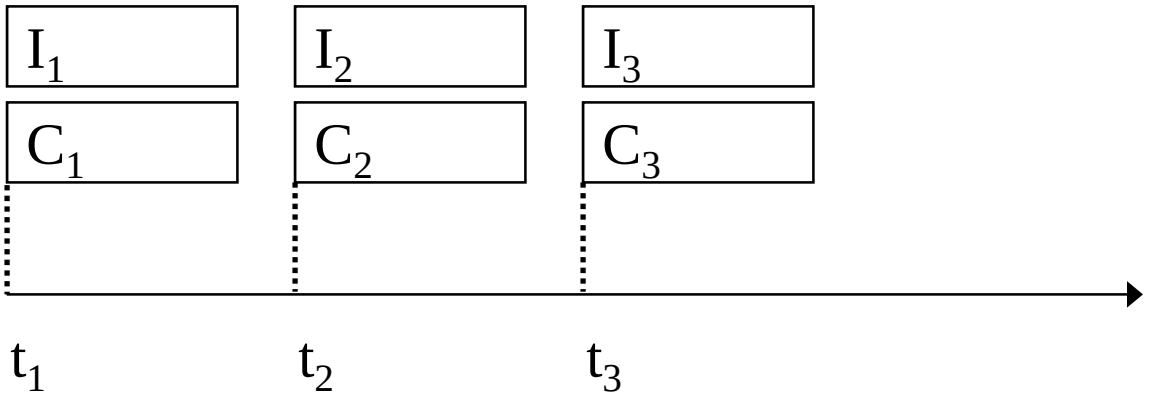
- Presentation events like start and end of presentation are mapped to axes that are shared by presentation objects
- All single medium objects are attached to time axis that represents abstraction of real-time
- This sync specification is very good for closed LDUs

Timeline Model (2)

- Uses a single global timeline
- Actions triggered when the time marker reaches a specific point along timeline

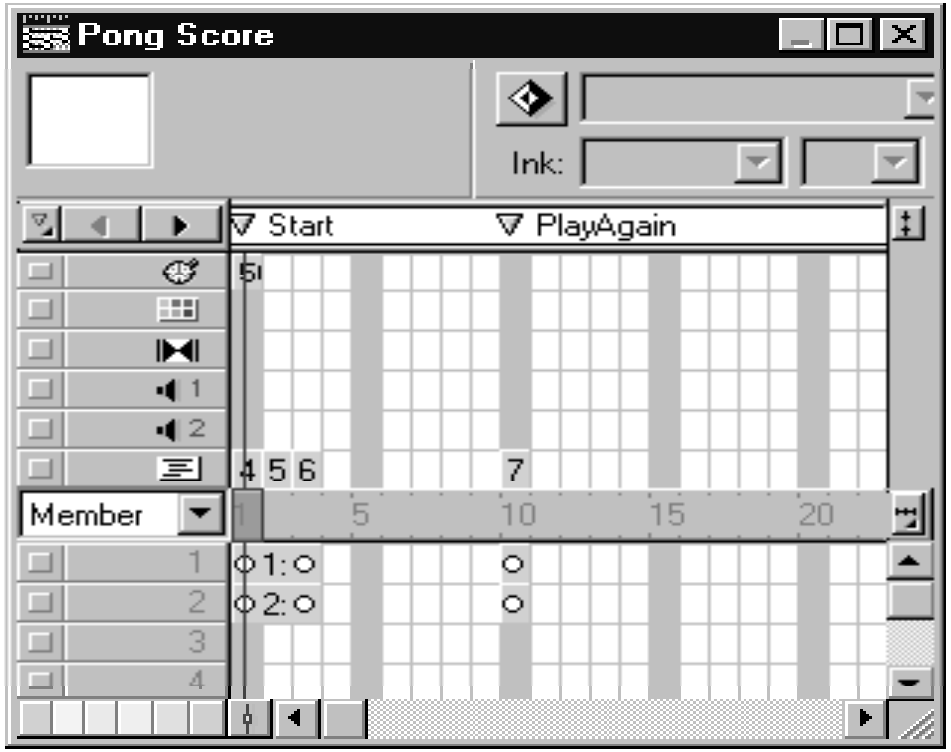
Example (3)

- Define a timed sequence of images, each image has a caption that goes with it



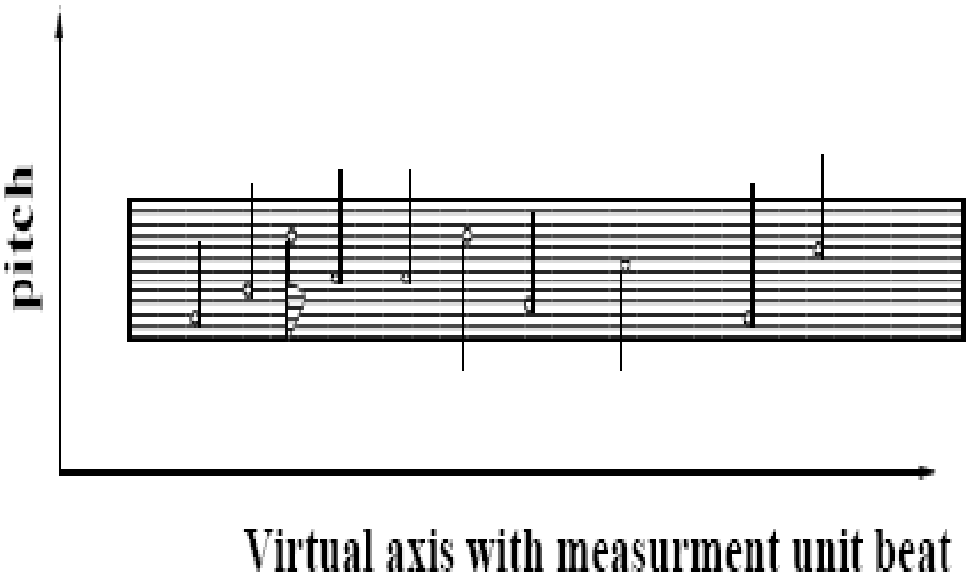
Example (4)

- Rule language
  - At (t1), show (I1, C1)
  - At (t2), show (I2, C2)
  - At (t3), show (I3, C3)
- Visual environment



Time-Axis-based Spec (based on Virtual Axis)

- Introduction of virtual axis – generalization of global time axis approach
- Possible to create coordinate system with user-defined measurement units
- Mapping of virtual axes to real axes done during run-time



Control Flow-based Spec - Hierarchical Model (1)

- Possibility to specify concurrent presentation threads at predefined points of presentation
- Basic hierarchical spec types:
  - Serial synchronization
  - Parallel synchronization of actions
- Actions: atomic or compound
  - Atomic action handles presentation of single media object, user input, delay
  - Compound actions are combinations of sync operators and atomic actions
  - Delay is atomic action – allows modeling of delays in serial presentations

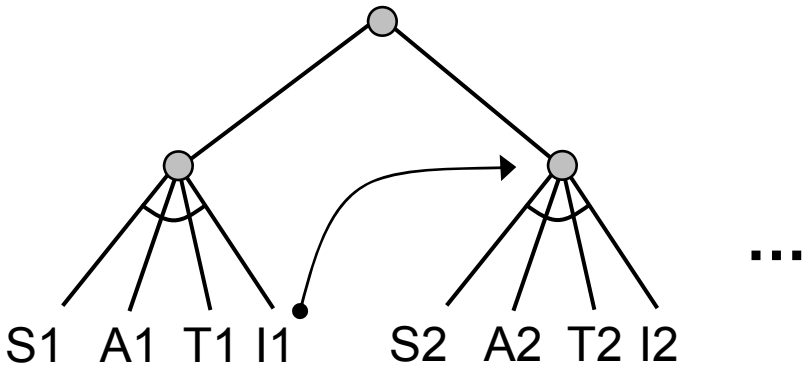
Hierarchical Model (SMIL)

- Based on sequential and parallel

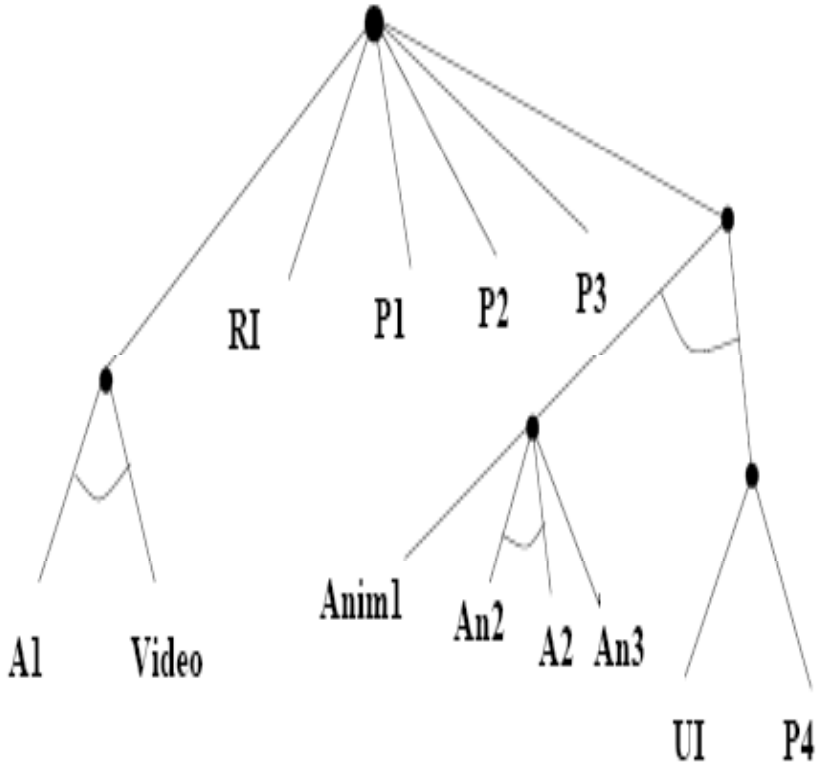
- Apply operators to only the start/end points of each media object

Example (3)

- Narrated slide show
  - image, text, audio on each slide
  - select link to move to the next slide



Example (4) (and Comparison with Interval-based Spec)



Audio1 while(0,0) Video

Audio1 before(0) RecordedInteraction

RecordedInteraction before(0) P1

P1 before(0) P2

P2 before(0) P3

P3 before(0) Interaction

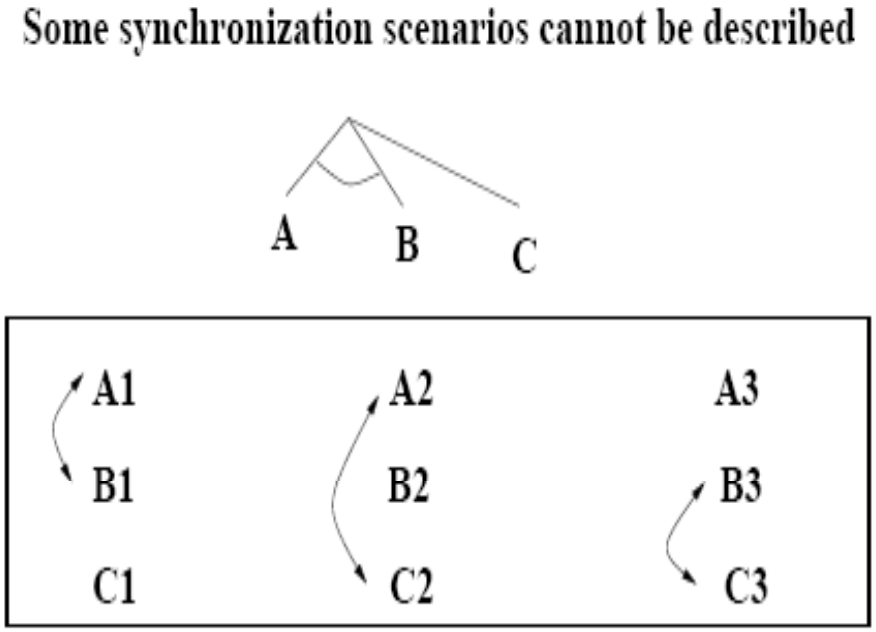
P3 before(0) Animation

Animation while(2,5) Audio2

Interaction before(0) P4

Control Flow-based Spec – Hierarchy (5)

- Advantages
  - Easy to understand
  - Natural support for hierarchies
  - Integration of interactive object easy
- Disadvantage
  - Need additional descriptions of skews and QoS
  - No duration description



Conclusion

- Synchronization Specifications
  - Important for different authoring tools for complex presentation
  - Be careful as you go from one spec to another
  - Carefully consider which spec closest allows you to specify sync requirements in your application