

TimeFlex:

Time Alignment for Improved Accuracy in Distributed Testing



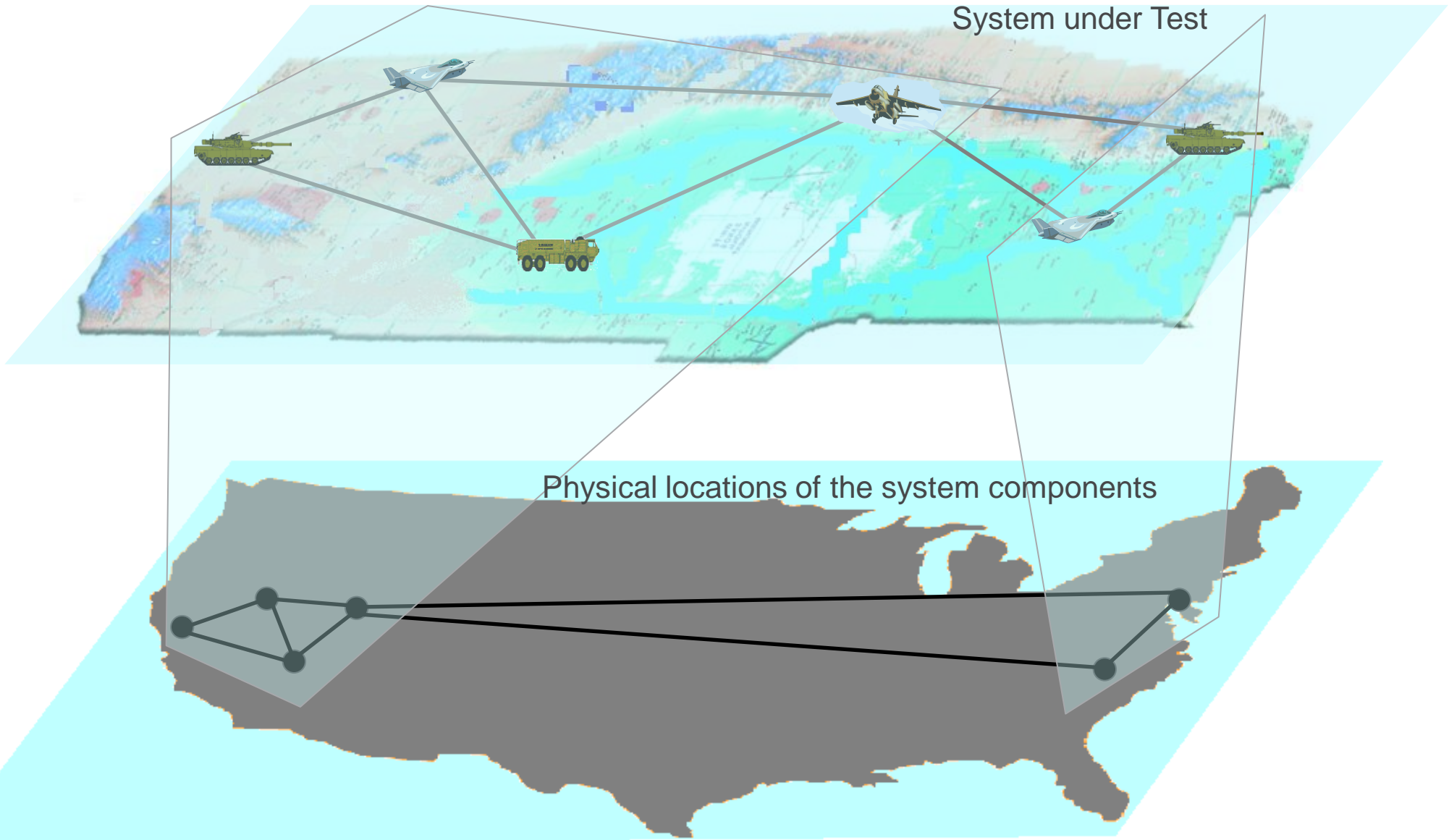
C. Jason Chiang, Constantin Serban
{jchiang,cserban}@appcomsci.com

November 14, 2013

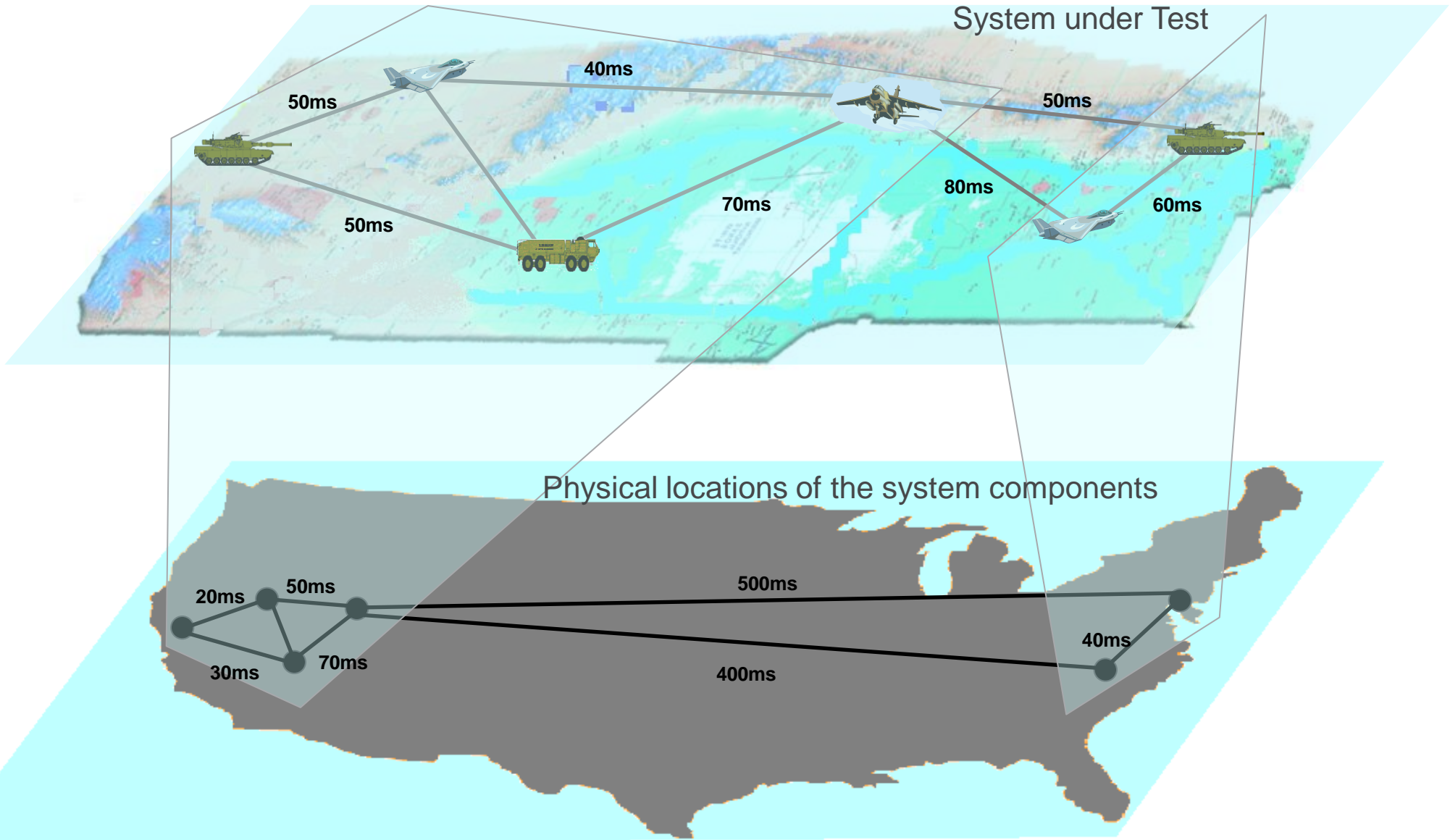
Problem Overview

- Distributed testing enables testing system of systems while not all components are co-located
 - The system components may reside on different sites across CONUS, however, they need to interact with each other in a joint testing exercise
- However, the inherent network latency between components could be an issue
 - For example, in a test scenario two system components on a wireless link are assumed to see 100ms link latency; however, the latency of the network used to connect the two could be 300ms
 - The problem is, the test cannot be executed accurately because of the additional network latency
- Many of the systems under test, or their simulation/emulation counterparts, can run on the computer

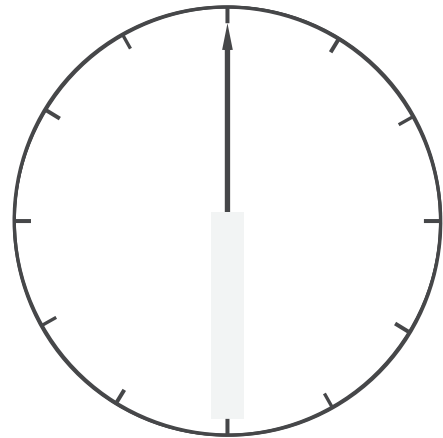
System Under Test



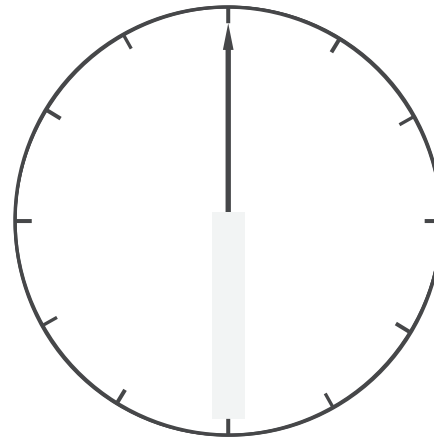
Virtual World Meets Reality



Clock Advancement: Real Time vs. Virtual Time



Real Time

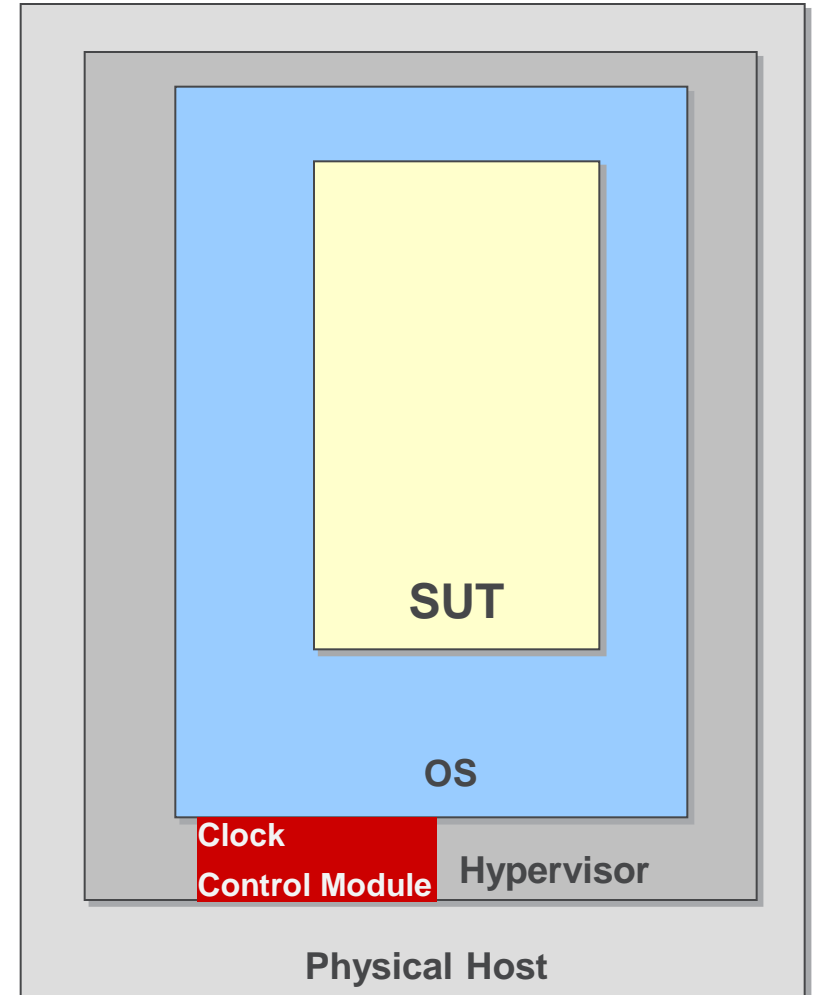
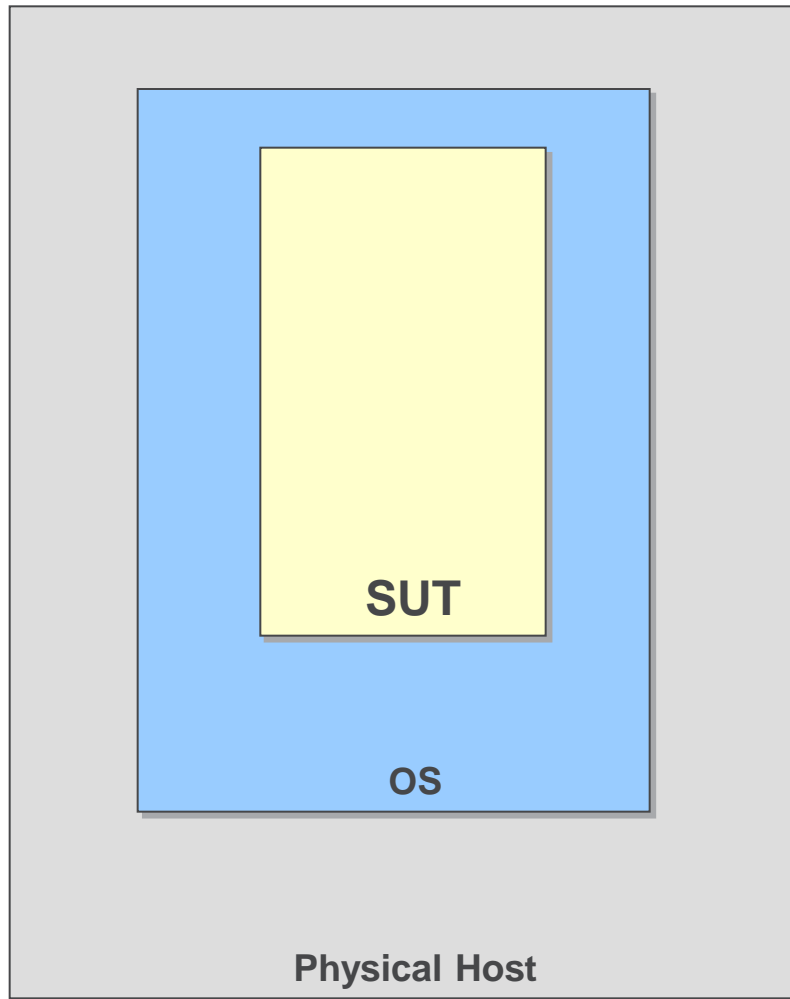


Virtual Time



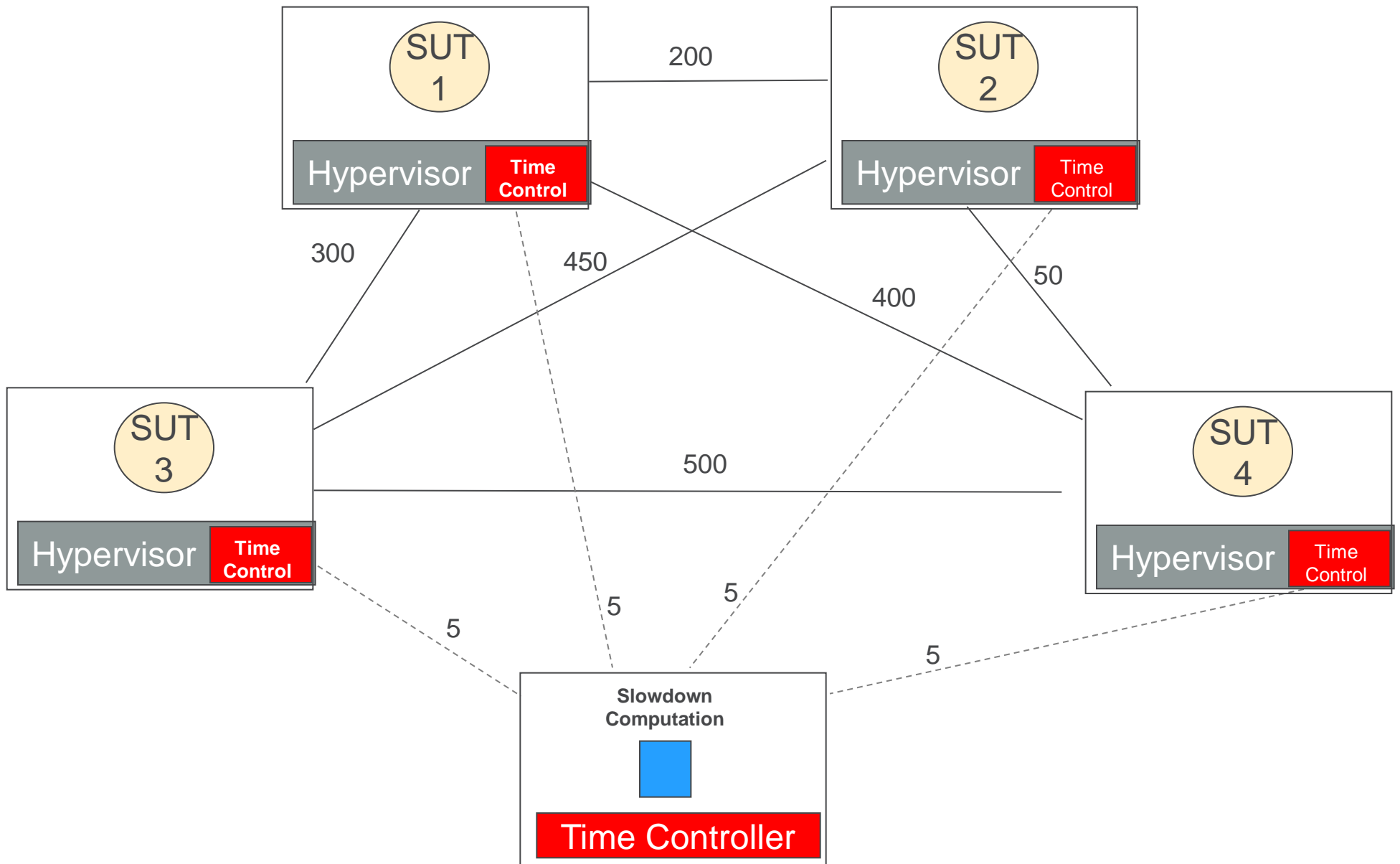
- According to real time clock, latency appears as 45s
- According to Virtual Clock, latency appears as 15s
- A slowdown factor of 3 in the clock rate produces a latency decrease by a factor of 3.

Slowdown Mechanism: Virtual machines



- Instead of executing SUT on OS/Hardware stack, execute SUT on OS/Virtualisation/Hardware stack
- Alter the time perception of an entire OS/SUT from the hypervisor layer
 - Completely transparent to OS, SUT (no modifications).

Time Flex in a real network



Time Flex Slowdown Implementation

- The algorithm was implemented for XEN Virtual Machines
 - Published papers available upon request
 - The implementation was tested on the VAN Testbed
- For a slowdown factor of 10 (i.e. 10 times slower than real time), our experiments showed great accuracy (error within 3ms)
- On a separate but related note, our time sync solution also works with a factor of 10 speed-up

LVC Exercise: no slowdown



The image shows a terminal window and an MPlayer video player window. The terminal window displays the following output:

```
atching colorspace  
ter: [scale]  
eo_out device is  
e scale filter to  
e instead of -vf  
ng pixfmt=2.  
atching colorspace  
ter: [scale]  
eo_out device is  
e scale filter to  
e instead of -vf  
1.34:1 - prescalin  
0 => 352x262 Plane  
t supported  
nal Xlib  
A-V: 0.001 ct: 1.763 1468/1468 0% 1% 0.1% 0 0
```

The MPlayer window shows a video of a road with several bounding boxes overlaid on it. The terminal window also shows the following output:

```
File Edit View Terminal Go Help  
64 bytes from 10.128.1.112: icmp_seq=14941 ttl=64 time=102 ms  
64 bytes from 10.128.1.112: icmp_seq=14942 ttl=64 time=101 ms  
64 bytes from 10.128.1.112: icmp_seq=14943 ttl=64 time=102 ms  
64 bytes from 10.128.1.112: icmp_seq=14944 ttl=64 time=100 ms  
64 bytes from 10.128.1.112: icmp_seq=14945 ttl=64 time=102 ms
```

LVC Exercise: slowdown

The image shows a terminal window with an MPlayer window overlaid on top. The MPlayer window displays a video of a road at night with yellow bounding boxes around objects. The terminal window shows the following output:

```
atching colorspace
ter: [scale]
eo_out device is :
e scale filter to
le instead of -vf
ng pixfmt=2.
atching colorspace
ter: [scale]
eo_out device is :
e scale filter to
le instead of -vf
1.34:1 - prescalin
0 => 352x262 Planar
supported
nal Xlib
7 A-V: 0.001 ct: 1.800 1458/1458 0% 1% 0.1% 0 0
```

The terminal window also shows network traffic:

```
File Edit View Terminal Go Help
64 bytes from 10.128.1.112: icmp_seq=15841 ttl=64 time=100 ms
64 bytes from 10.128.1.112: icmp_seq=15842 ttl=64 time=100 ms
64 bytes from 10.128.1.112: icmp_seq=15843 ttl=64 time=100 ms
64 bytes from 10.128.1.112: icmp_seq=15844 ttl=64 time=103 ms
64 bytes from 10.128.1.112: icmp_seq=15845 ttl=64 time=101 ms
```

Summary

- Physics and network latency cannot be overcome; however, the perception of time could be altered