2018 DESIGN AND VERIFICATION™ DVCON CONFERENCE AND EXHIBITION UNITED STATES

Transparently Checkpointing Software Test Benches to Improve Productivity of SOC Verification in an Emulation Environment

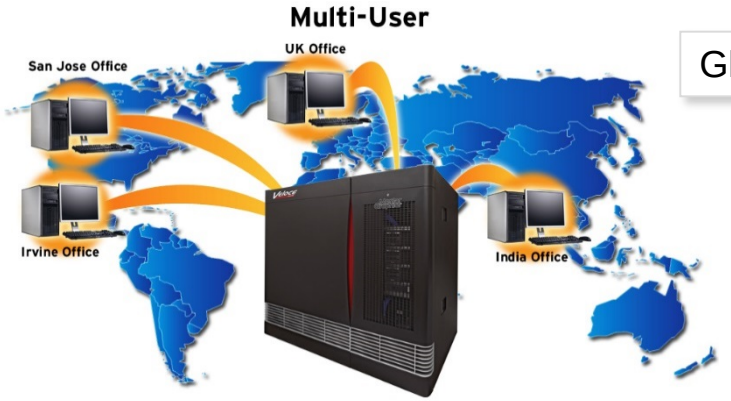
{**Ankit Garg**, K. Suresh, Jeff Evans}, Mentor, A Siemens Business,

{Gene Cooperman, Rohan Garg}, Northeastern University

Mentor® A Siemens Business

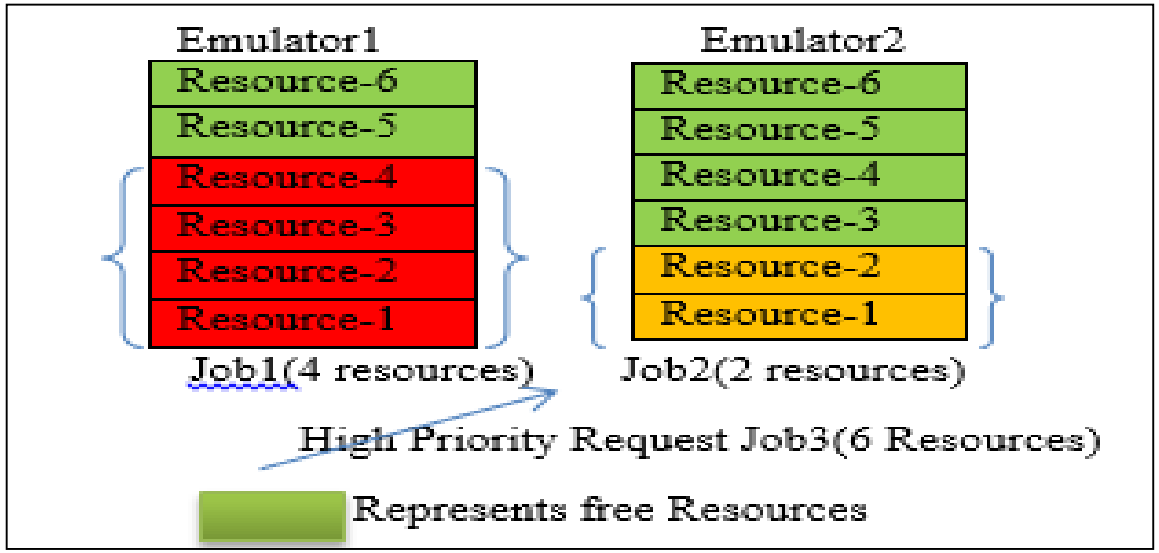
Emulator as Enterprise Platform

- Emulation moved to Virtualization
  - Virtual Data center friendliness
  - Enterprise level usage
  - Moved to Application age



Efficient Emulator Utilization Desired

- Emulators allow jobs sized as integral multiple of minimum partition size
  - Complexities for job scheduling as jobs can be of varying sizes
- Non-preemptive nature of Virtual Emulation jobs results in inefficiencies and under utilization of resources
- Underutilization of expensive resource like Emulator directly affects cost of ownership



Making Virtual Emulation Jobs Preemptive

Solution:

- Checkpoint-Restore can solve problem of non preemption

Challenges:

- Virtual Emulation Jobs requires checkpoint-restore of two parts
  - Hardware Checkpoint-Restore: available for many years
  - Software Testbench Checkpoint-Restore: an elusive problem to solve
    - Virtual testbench environments can be non-deterministic, multi-threaded/process
    - Involves multiple languages like C/SystemC, SystemVerilog, etc.

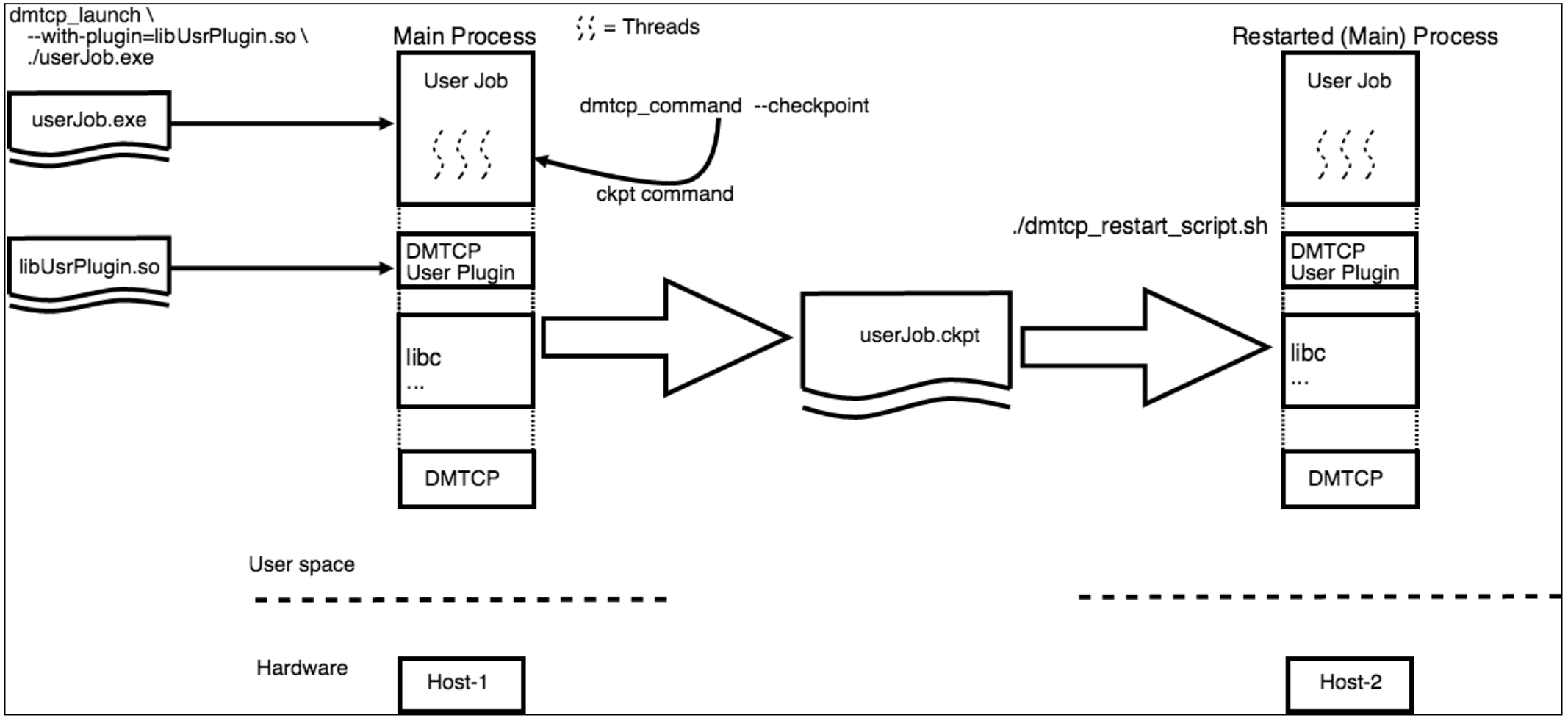
Software Checkpoint-Restore

- Application-level checkpoint-restore
  - Difficult to maintain, complicated with multiple languages involved
  - Requires changes in user code; third-party libraries add more complexities
- Checkpoint-Restore supported by kernel modules
  - Requires root privileges
  - Difficult to maintain: closely coupled with kernel, which has frequent changes
- Replay Software testbench using stimulus from the hardware
    - Time consuming; capturing all stimulus may result in large database size
- Transparent checkpoint-restore without change to user code or kernel

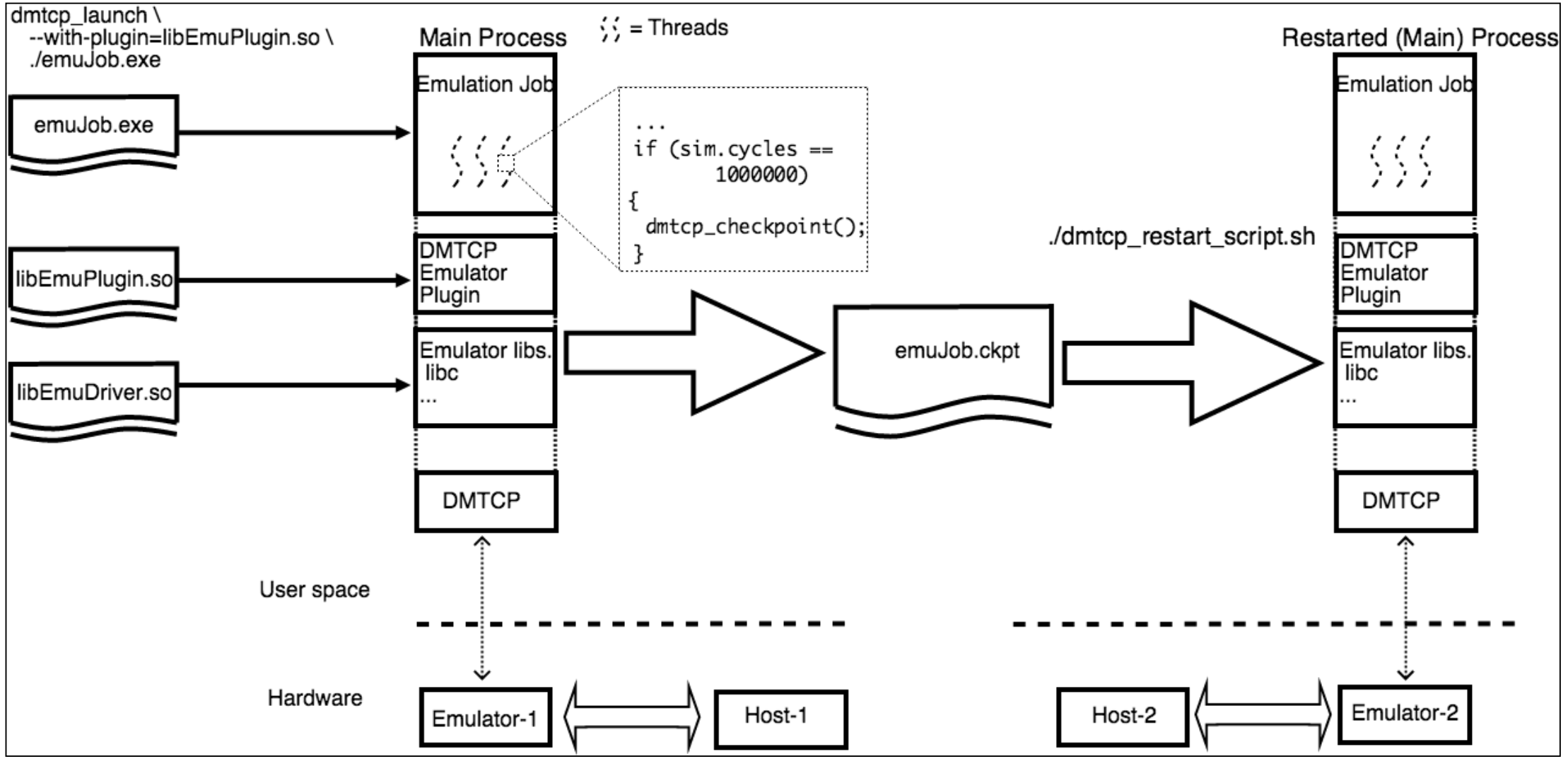
Background - DMTCP

- DMTCP: Distributed MultiThreaded Checkpointing
  - Open source tool: http://dmtcp.sourceforge.net
  - Transparently checkpoint-restores state of running application
  - Operates directly on user binary executable
    - No root privileges needed
    - No loading of kernel modules
    - No application source code change needed
    - No re-linking/re-compilation needed
  - Mature: 11 years in development
  - Robust user base with more than 11 thousand downloads

DMTCP Generic Application Checkpoint/Restart

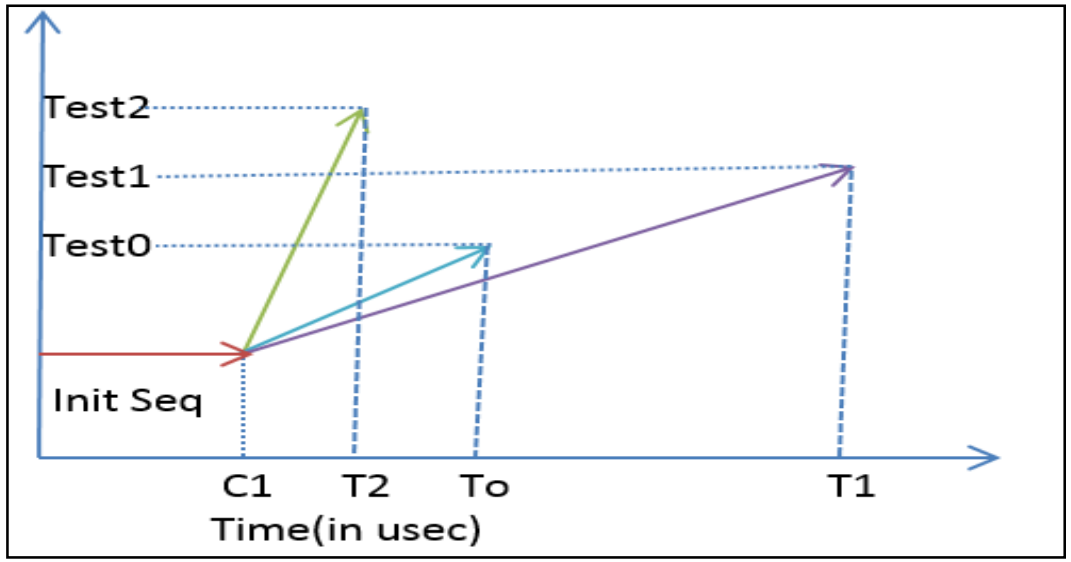


DMTCP Emulation Application Checkpoint/Restart



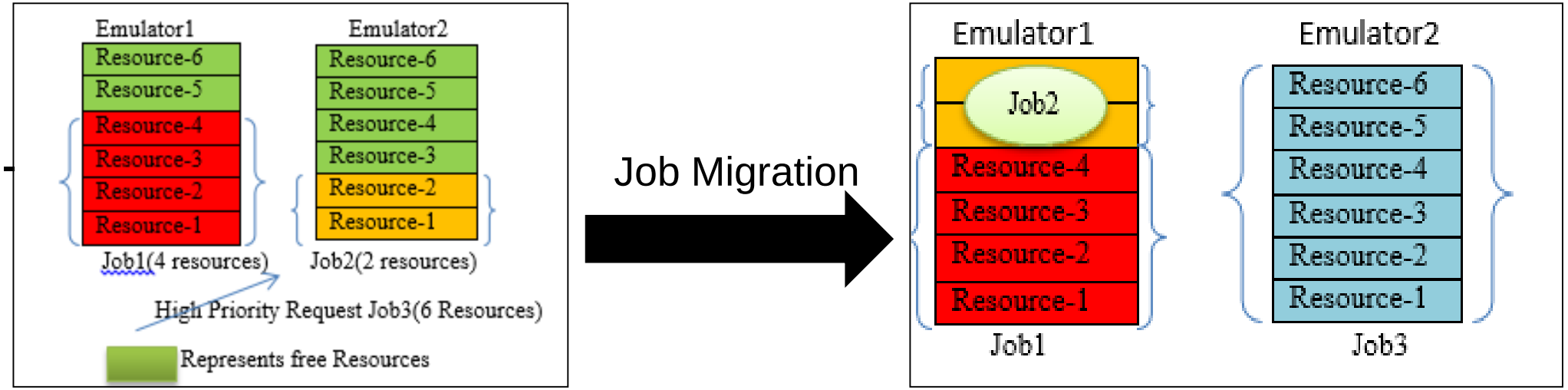
Motivating Use Cases (I)

- Skipping repeated initial sequence
  - E.g. hardware reset phase or boot-up
  - Large runtime time after which actual test start
  - Can save lot of emulation runtime by taking checkpoint right after this repeated sequence



Motivating Use Cases (II)

- Better Job Management Policies
  - Enable a Pre-emptive scheduling policy
  - Job migration possible leading to more efficient Emulator utilization
  - Large capacity jobs having low priority will get fair chance to execute

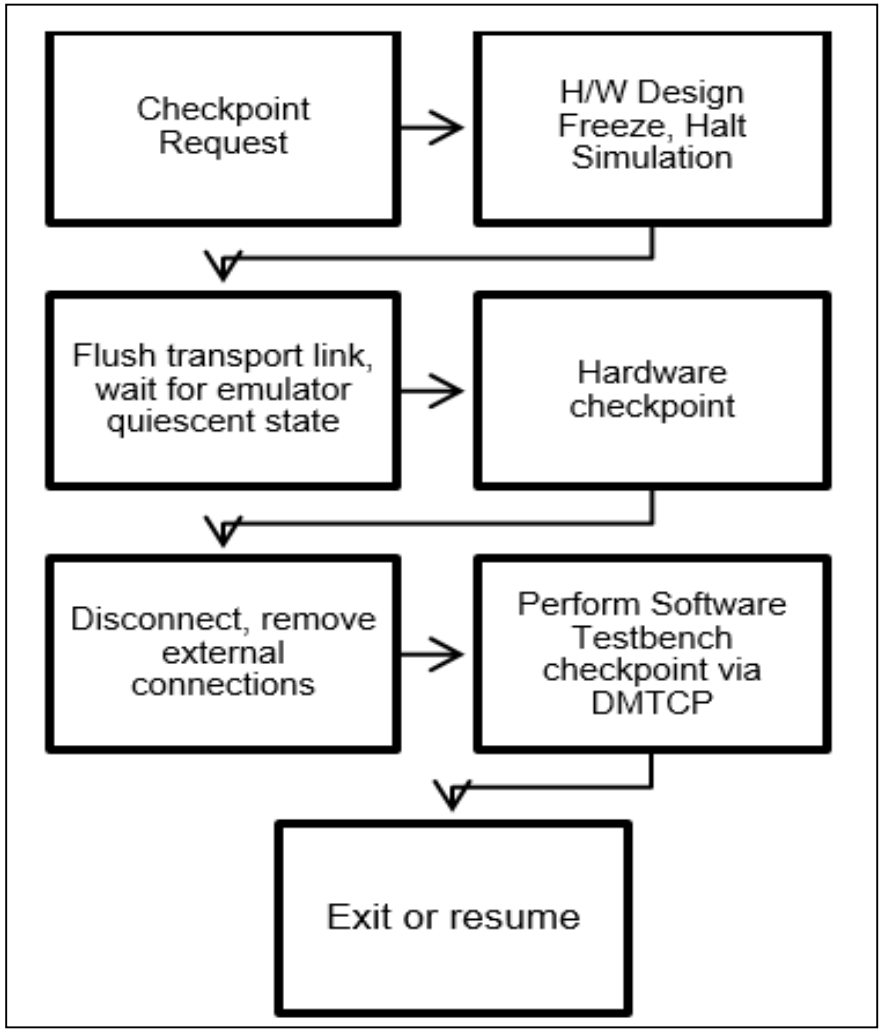


Motivating Use Cases (III)

- Debugging from past simulation time
  - Full system Checkpoint capability let engineers debug just prior to first appearance of issue
  - Save lot of time in case issue occurs only after a run of long duration
  - Users can take periodic checkpoint and restart from the corresponding window

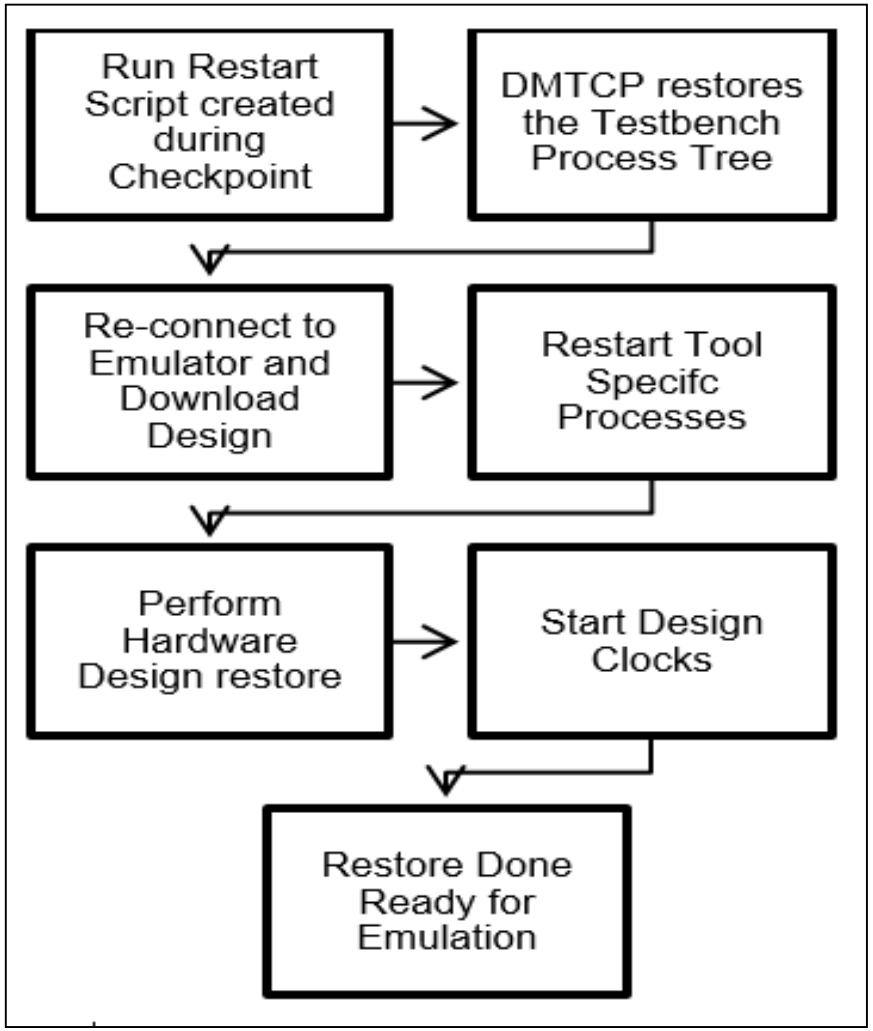
DMTCP Emulation Integrated Checkpoint flow

- Flowchart describing steps taken for checkpointing two parts
  - Hardware checkpoint is done by Emulator
  - Software checkpoint is done by DMTCP



DMTCP Emulation Integrated Restart/Restore flow

- Flowchart describing steps for restoring two part
  - Process tree is restored by DMTCP
  - Hardware State is restored by Emulator



2018 DESIGN AND VERIFICATION™ DVCON CONFERENCE AND EXHIBITION UNITED STATES

Case Study: Skipping The OS Boot In An OEM Company's SOC Validation Environment

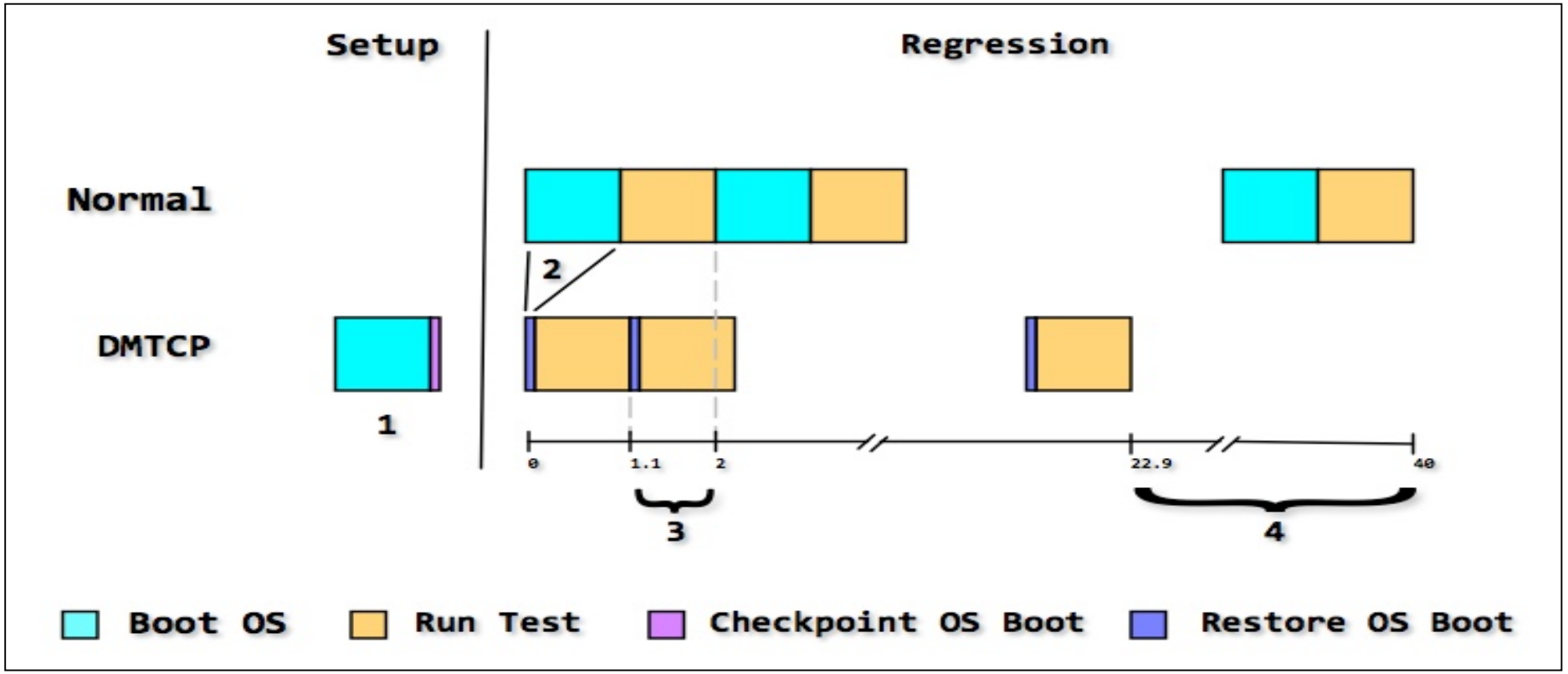
- SOC consists of a CPU, Memory subsystem, switching fabric and peripherals
- Hybrid environment
  - Part of SOC modeled on workstation
  - Part of SOC modeled in emulator
- SOC validation required booting an OS to run applications being validated
  - Boot of the OS takes on the order of hours to days
- DMTCP eliminated OS boot time allowing more applications to run per user per day

Case Study: Skipping The OS Boot In An OEM Company's SOC Validation Environment

- Regression suite consists of 20 jobs
- Each job similar profile around 1 hour OS boot and 1 hour of execution
- DMTCP based checkpointing was used to checkpoint just after boot
- Restoration takes around 5 minutes

Case Study: Results

- Regression suite emulation time comparison



Case Study: Challenges and Solutions

- Large files were getting checkpointed increasing checkpoint time and database size
  - DMTCP emulation plugin created a skip list for read only files

- Checkpoint database was not portable to another site
  - File paths were preserved during checkpointing
  - This was solved using file path virtualization plugin of DMTCP
  - This allowed file paths to be changed at restore time

Next Steps

- Work on developing pre-emptive capabilities for emulation jobs
- Integrate job migration capability to make job scheduling more flexible
- Discover practical challenges in deployment
- Some use cases have a remote process on Windows machine, additional work is required on this front

2018 DESIGN AND VERIFICATION™ DVCON CONFERENCE AND EXHIBITION UNITED STATES

Questions?