Parallel Discrete Event Simulation

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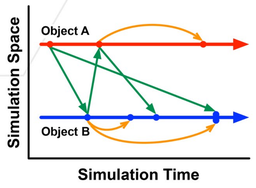
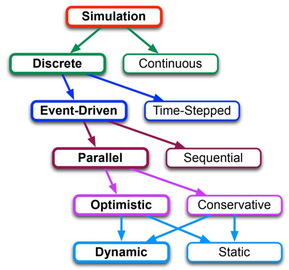
Discrete Event Simulation is the tool of choice for problem domains without governing physical (differential) equations. Our R&D effort is focused on faster execution of the largest models in parallel and faster development of models through better simulator tools. Application spaces include biology, communications, and critical infrastructure.

DISCRETE EVENT SIMULATION

Simulation approach for problem domains where state changes are modeled as a sequence of discrete changes (events). (Contrast with continuous simulation in which state is changed continuously over time based on a set of differential equations.)

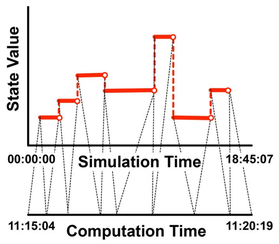


- Objects act at discrete points in time (and space): discrete events
- Objects interact by sending messages to be acted on at a future time



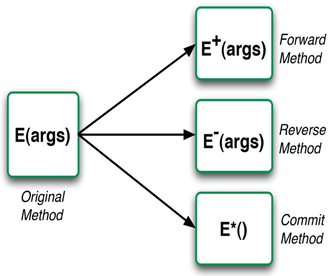
Large models and faster time to solution require *parallel* execution.

- Biggest challenge is *synchronization*
- Second biggest challenge is *load balancing*



- Computation time is used to update new state values when an event occurs
- No computation required to move between event times

XPDES: NEW, UNIFIED APPROACH TO SYNCHRONIZATION




```
E(args);   ≡   E+(args) ; E*();
{} /* no-op */          ≡   E+(args) ; E-(args);
```

- Application models are hard to write
- Optimistic models are triply hard to write: need to factor event method in to three related pieces
- Backstroke compiler tool automates this process

ns-3 NETWORK SIMULATOR

UVT

Charm++

ROSE

XPDES

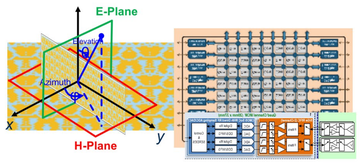
XPDES: eXtreme-scale PDES combines:

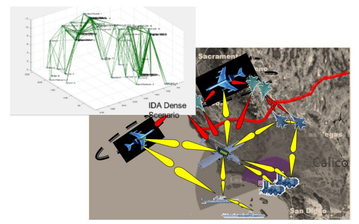
- Backstroke: automatic optimistic code generation
- New universal virtual time synchronization algorithm
- Charm++ dynamic load balancing

EXAMPLE PDES APPLICATIONS

Using a simulator as integration point for **first-of-kind networked radio**:

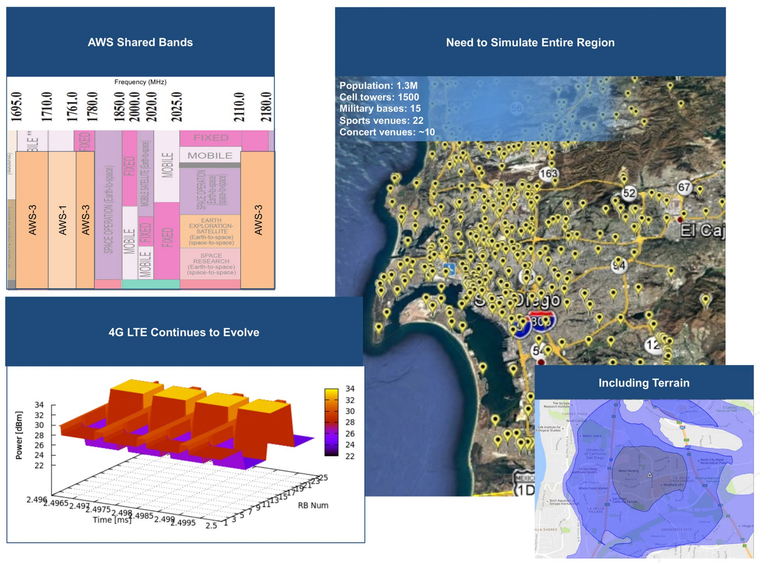
- Novel hardware, requiring significant advances in model and simulator technology
- Novel network management protocols require testing in adverse conditions at system level
- Hardware, firmware, and protocol performance all being demonstrated and integrated first in simulation
- Demonstrate performance in mission-relevant scenarios



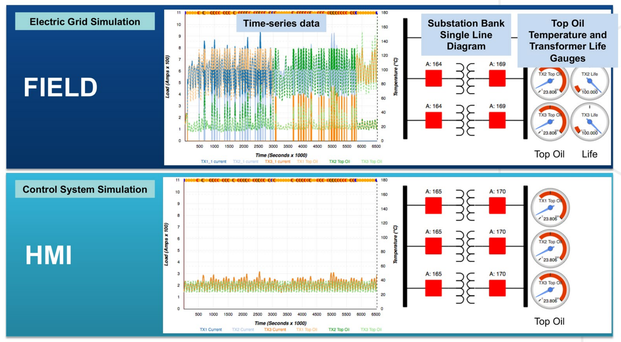


Modeling **mutual interference** between cell phone and government users:

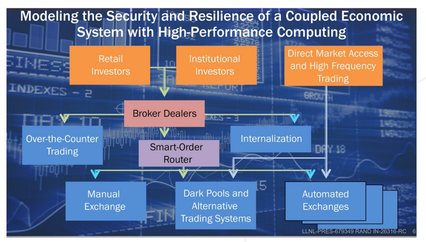
- Improve assessment of mutual interference between DoD and current 4G and future 5G cell phone (LTE) technology
- Tools to support DoD tactical use of LTE



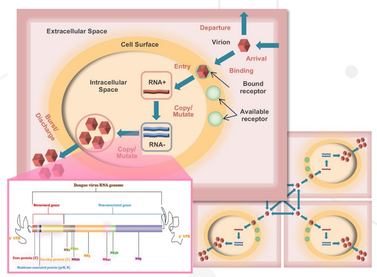
Co-simulation of electric grid and control system as a testbed for advanced approaches to **critical infrastructure security**:



Discrete simulation applied to **novel science and security** domains:



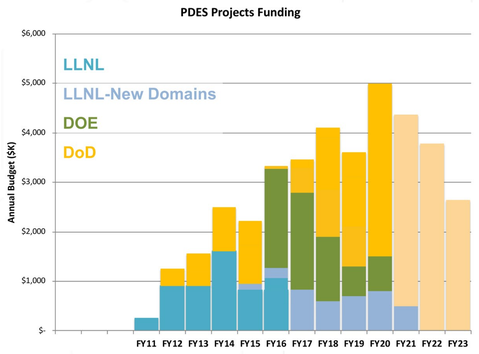
Behavioral and structural model of the U.S. stock market to study questions of policy, stability, and indicators of manipulation and instability.



Discrete model for the evolution of viruses as they replicate in human cells. This is intrinsically a continuous chemical process. By using a DES approach, we can model many more cells over much longer times.

SPONSORS

LLNL investment ➔ sustained external sponsorship. Continued LLNL investment aimed at demonstrating new application areas.



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LDRD

NNSA National Nuclear Security Administration

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