



PSCAD V5

A General Overview of High Performance Computing in PSCAD V5

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AGENDA

- Introduction
- Two paradigms and their requirements
- Enhancements in V5 – in terms of HPC
- Demo
 - Parallel Multiple Run (PMR)
 - Parallel Network Interface (PNI)
- Cluster Launch System (CLS)
- Come on-board – try before you buy

Why High Performance Computing?

- Computer based EMT simulations have been used by engineers to design and create power equipment
- In early 70's to year 2000
 - Complexity of electric networks was localized
 - Complexity of computer modelling of equipment involved was manageable on single core computers
 - Scenarios and contingencies were manageable in a single simulation

Why High Performance Computing?

- Grid Modernization, resilience studies and use of complex HVDC, renewables and FACTS devices, increased size of study area network that has to be considered
 - Computation has become complex
 - Area of study has grown – *time and complex*
 - Renewables energy sources – *complex*
 - Number of scenarios or operating conditions – *time*
 - Nature of faults has changed
 - Electrical
 - Evolving threat types - natural disasters, attacks, cyber attacks, etc.

Why High Performance Computing?

- Size of network
- Diversity in the contingencies
- Complexity and detailed models of equipment has led the simulations from being manageable to unmanageable on a single computer (conventional computing)

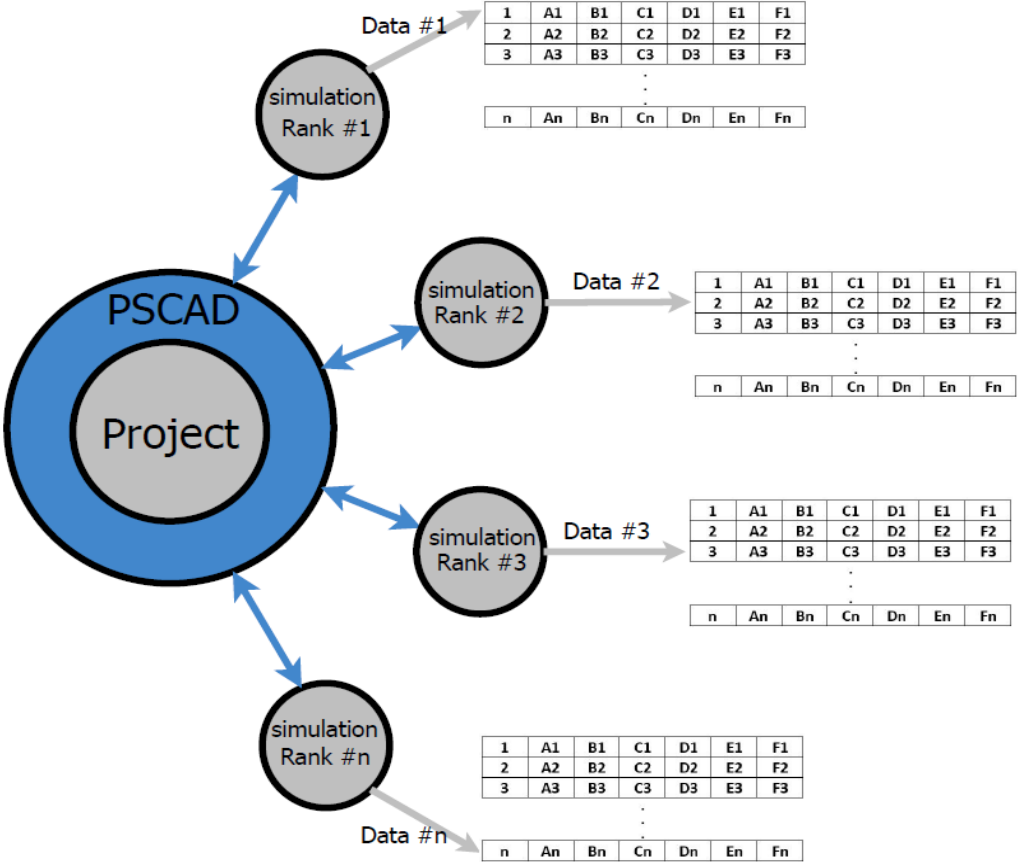
Parallel and HPC has the ability to
manage scale and complexity

Two Paradigms and their requirements

There are 2 major parallel computing paradigms supported in PSCAD (4.6.3 and 5.0.0)

- Parallel Multiple Run (PMR)
 - A single simulation running multiple times (multiple-run situation)
 - Single simulation executable (.exe) is launched multiple times simultaneously.
 - Each run evaluates a separate parameter set.
 - E.g., parametric study, contingency study, etc.
 - Each run is independent from the other.
 - Computation intensive.
 - **Very LOW communication requirements.**
 - **Feature name – Parallel Multiple Run (PMR)**

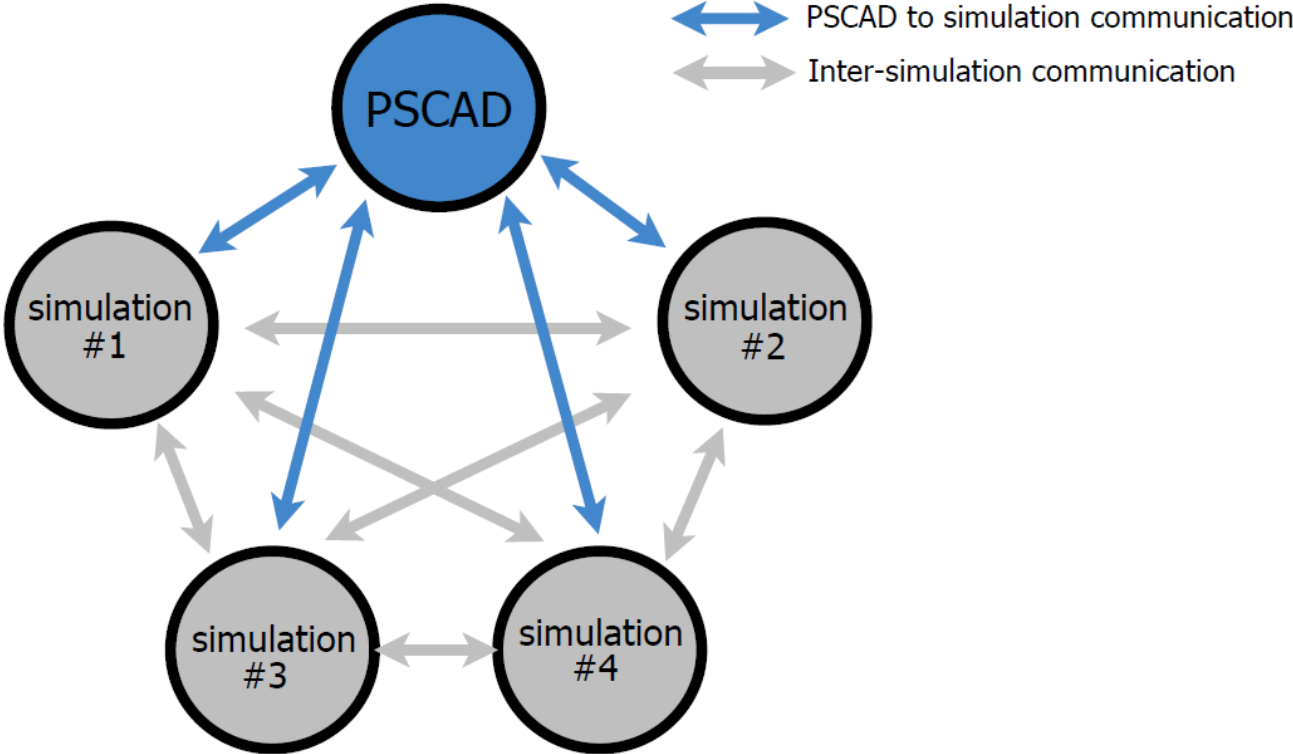
Parallel Multiple Run (PMR)



Two Paradigms and their requirements

- Parallel Network Interface (PNI)
 - A single large network is broken into multiple smaller networks and run simultaneously
 - All the smaller network are connected to each other via Transmission Lines.
 - At runtime, networks exchange current and voltage values via Transmission Line interface.
 - The exchange of values happens every time-step of simulation.
 - Each simulation process (smaller network) is in lock-step with the other.
 - Computation intensive.
 - **Very HIGH communication requirements.**
 - **Feature name – Parallel Network Interface (PNI)**

Parallel Network Interface (PNI)



Enhancements in V5 – in terms of HPC

- New Communication Fabric – ComFab
 - Smart communication protocol manager
 - Supported communication protocols
 - TCP
 - Shared Memory
 - Network Direct (Remote Direct Memory Access (RDMA)/RoCE) – **on demand**

Packet Size	Protocol	Localhost	Inter-machine
64 B	TCP	20.0 us	230.0 us
	SHMEM	0.9 us	N/A
	RDMA	0.9 us	~1-2 us

Enhancements in V5 – in terms of HPC

- Reduced number of communication channels between simulations
 - Only 1 communication channel between 2 simulations
- Better core usage in V5
 - PNI can overload the cores and yet perform better.

Performance Test Results

Case Name	All-in-one Single Process (sec)	Protocol	Single Node Localhost (sec)	Multi-Node Across Hosts (sec)
Simple AC Network	14	TCP	25	252
		SHMEM	5	N/A
		RDMA	N/A	7
P2P HVDC (CIGRE Benchmark)	44	TCP	62	351
		SHMEM	18	N/A
		RDMA	N/A	21
Wind Park Type 3 DFIG x 38	1850	TCP	587	2127
		SHMEM	253	N/A
		RDMA	N/A	262

PNI setup of 354 Simulations across 7 computers with mixed communication

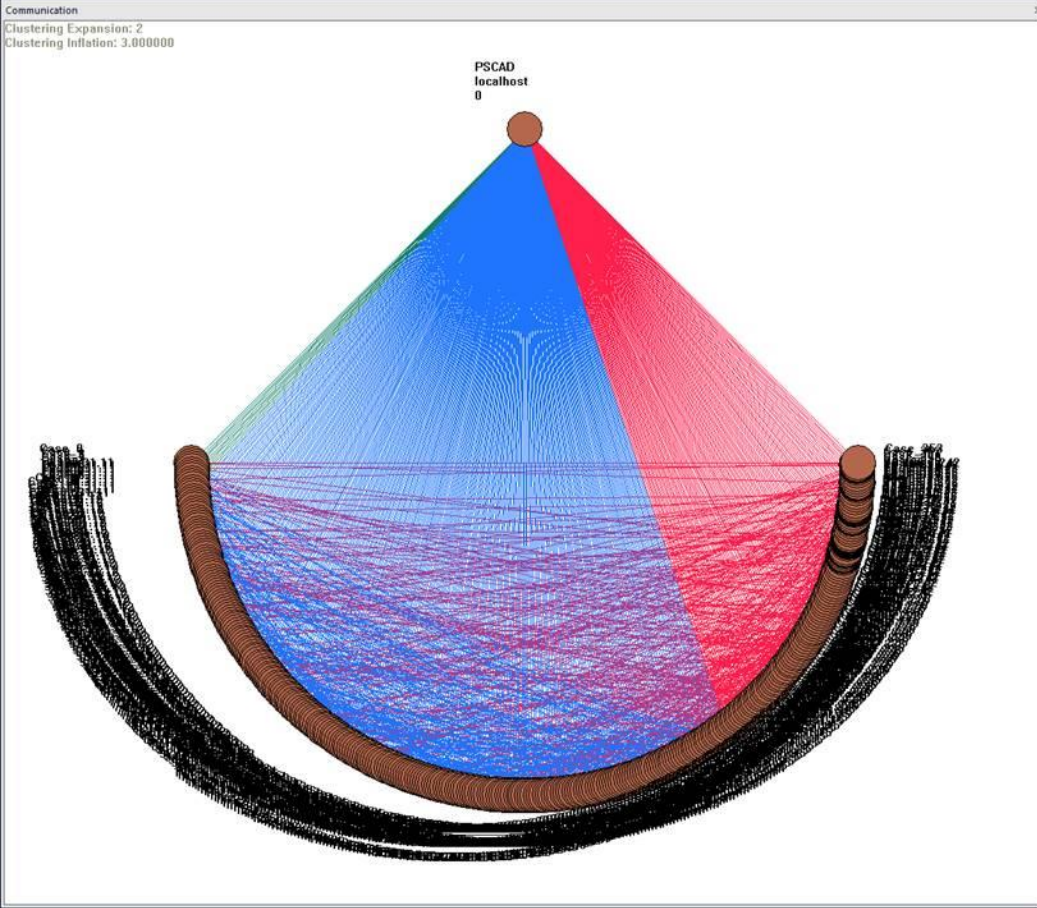
- Shared Memory
- RDMA
- TCP

Run-time Environment

IP Address	Core Count
10.100.31.11	10
10.100.31.12	80
10.100.31.13	80
10.100.31.14	80
10.100.31.15	24
10.100.7.226	40
10.100.7.242	40

Connected via
InfiniBand/RoCE
Switch

Only TCP
supported
for remote
connection





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Parallel Multiple Run (PMR)

Demo



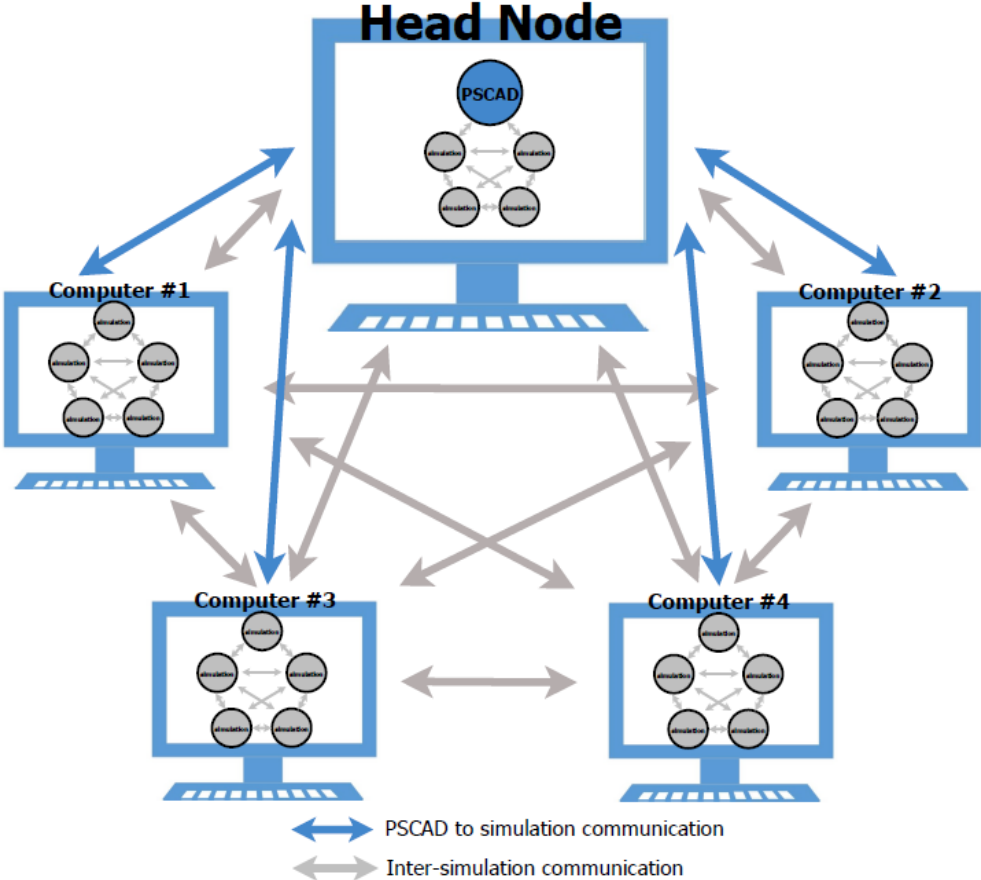
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Parallel Network Interface (PNI)

Demo

Cluster Launch System

- Launch of simulations on remote workstations
- Create on-the-fly computational cluster to run very large PNI or PMR configuration
- Only one PSCAD license required





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Cluster Launch System (CLS)

Demo

Come onboard – try before you buy





Thank you!

For question please contact us:
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