Automated Derivation of Application Workload Models for Design Space Exploration of Distributed Cyber-Physical Systems

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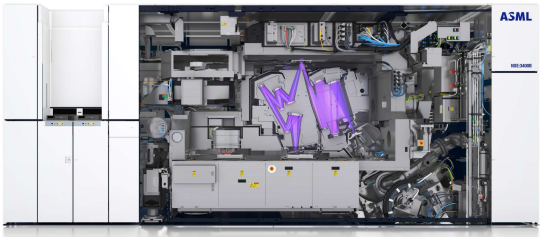
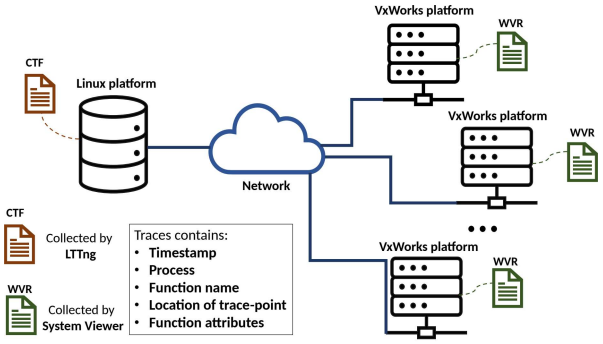
Scientific Challenge

Efficient and scalable Design Space Exploration (DSE) of Industrial Cyber-physical systems requires a comprehensive software application workloads model. This model should possess several essential characteristics:

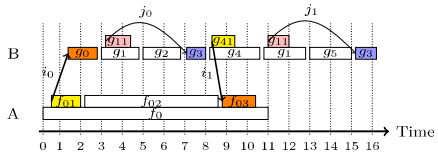
- **Abstract and coarse-grained**
- **Timing and architecture agnostic**
- **Dependency-aware**
- **Mode-aware**



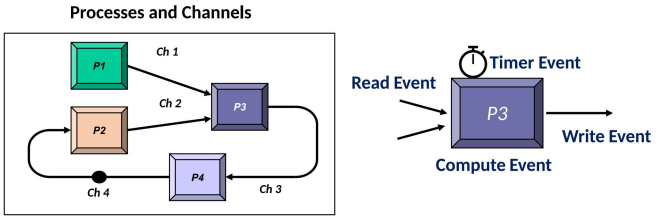
Tracing of Distributed Systems



timestamp	*process*	*function*	*location*	*class*	*id*	*msgsize*	*duration*
0	A	f_0	start				
0.5	A	f_{01}	start	send	i_0	40	
1.4	B	g_0	start	receive	i_0	40	
2.0	A	f_{01}	end	send	i_0	40	
2.15	A	f_{02}	start				
2.85	B	g_0	end	receive	i_0	40	
3.0	B	g_1	start				
3.1	B	g_{11}	start	trigger	j_0		4
⋮	⋮	⋮	⋮				
16.25	B	g_3	end	handler	j_1		4



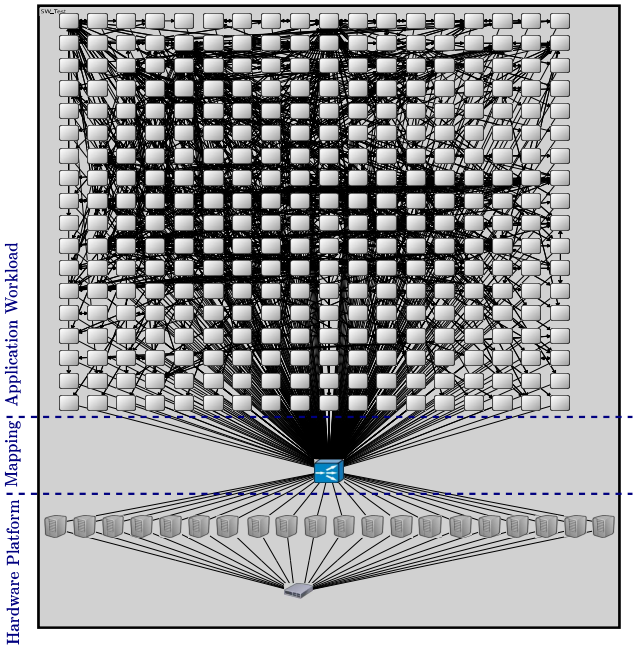
Application Workload Model



Events:

- **Communication Events (Read and Write):** Modeling message exchange and synchronization between processes through channels
- **Computation Events:** Modeling computation actions with an abstract workload signature.
- **Timer Events (Timer Setter and Timer Handler):** Modeling internal triggers that originate within a process and initiate a computation or communication event after a specific amount of time has elapsed.

Simulation



Using OMNET++ Discrete Event Simulator

Event file:

Order	EventType	dstP/srcP/ID	#cycles/Time	#bytes
1	Read	← A	10	40
2	Computation		40	
3	Timer Setter	$id:0$	4s	
4	Computation		33	
5	Timer Handler	$id:0$	4s	
6	Computation		62	
7	Write	→ A	13	73
8	Computation		20	
9	Timer Setter	$id:1$	4s	
10	Computation		30	
11	Timer Handler	$id:1$	4s	
⋮	⋮	⋮	⋮	⋮

- **Application Workload Model**: Consists of hundreds of processes and channels and each process has an individual event file
- **Mapping Model**: Forward the events of a process to the corresponding subsystem allocated to execute the process
- **Hardware Platform Model**: Responsible for simulating the timing consequences of the workload events issued by processes. It consists of subsystems and networks.

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