The Distributed-SDF Domain

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Overview

- **Motivation**
- **What is the Distributed-SDF domain?**
- **How to use it?**
- **Calculation of the parallel schedule**
- **Client / Server Approach**
- **The Server**
- **The Client**
- **Software packages**
- **Further Work**
- **Conclusions**

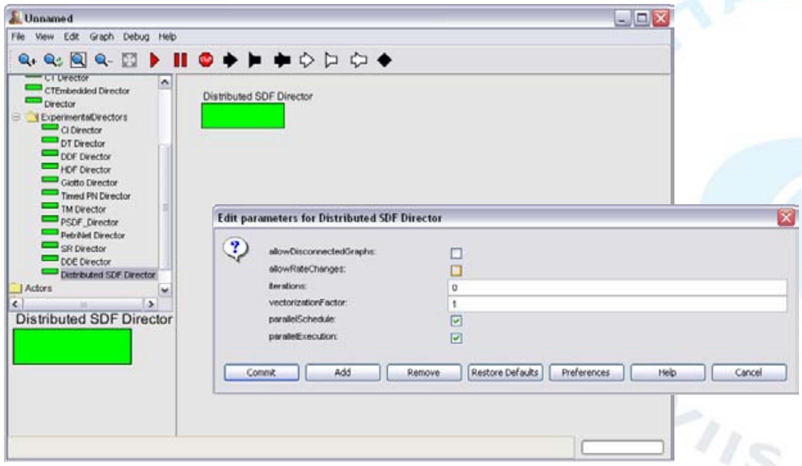
Motivation

- **Ptolemy simulations are performed in one machine**
  - Sequentially or threaded (but sharing the same CPU)
- **Memory limitations**
  - Locally installed memory
  - JVM
- **Why SDF?**
  - Dataflow is a good candidate formalism for distribution
  - Allows for static scheduling
  - One of the most popular

What is the Distributed-SDF Domain?

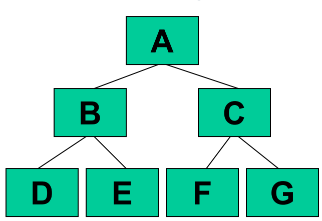
- **Extended version of the existing SDF Domain that performs the simulation in a distributed manner**
  - Smaller simulation times
    - For models with some degree of parallelism
    - Specially those where cost(computation) > >> cost(communication)
  - Allow bigger models (in terms of memory)
- **Exploits the degree of parallelism many models expose in their topology**
- **It is transparent to the user**
- **It requires a distributed platform to perform the simulation**
- **Keep the existing architecture untouched and only extending it**

How to use it?



Calculation of the parallel schedule

- **To take advantage of the inherent parallelism of the model we need to generate a parallel schedule to determine which actors can be executed in parallel**
- **Performs a topological sort of the graph that can be constructed with the data dependencies among the actors**
  - The existing SDF Scheduler produces schedules in a deep-first fashion.



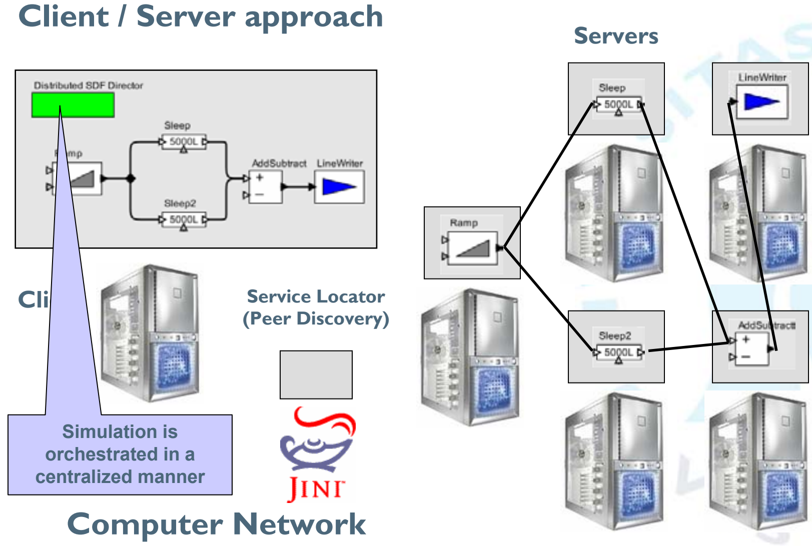
Sequential: (A B D E C F G)

Parallel: ((A) (B C) (D E F G))

t(A) + … + t(G) > t(A) + max(t(B),t(C)) + max(t(D),t(E),t(F),t(G)) + toh

Time overhead = communication + initialization <<< simulation time

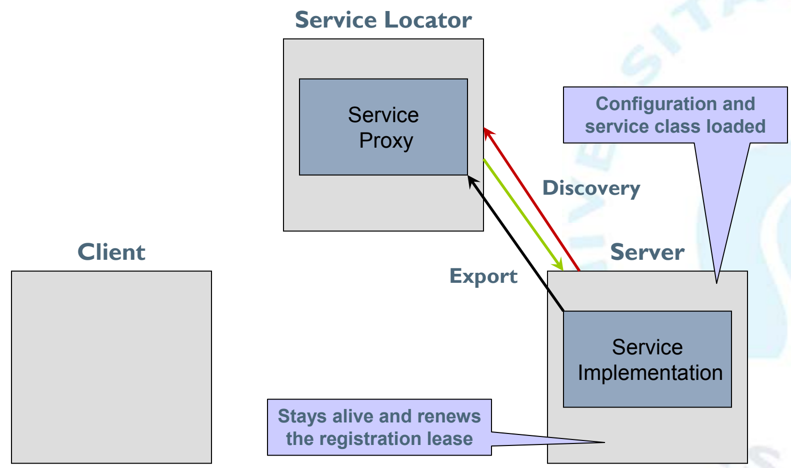
Client / Server approach



The Server

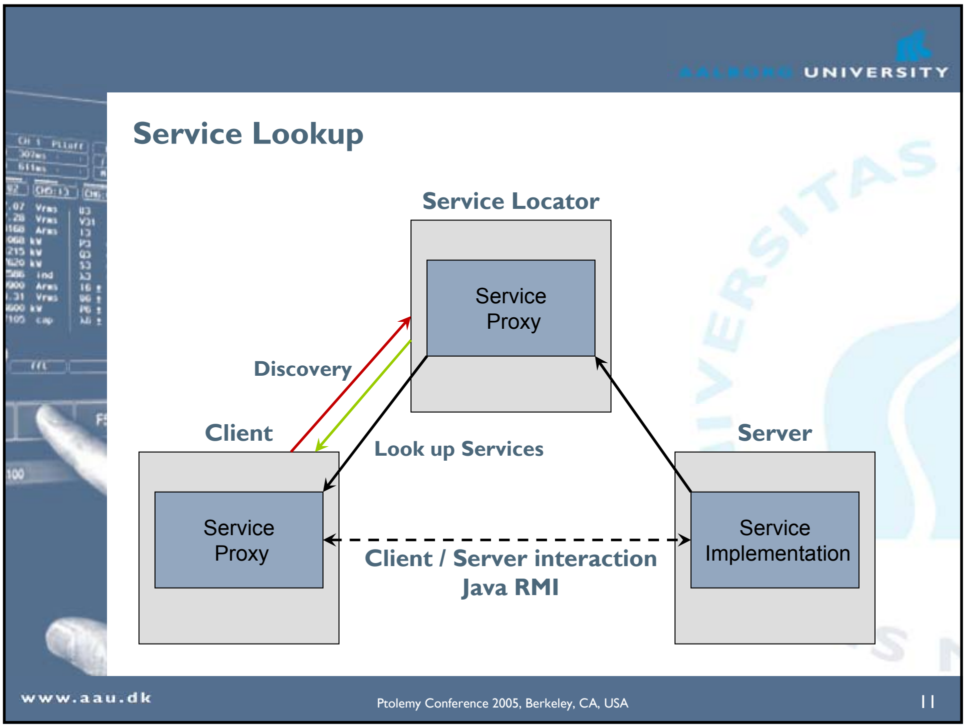
- **Prepares for discovery of a service locator**
  - Loads various settings as for example:
    - Unicast locators (predefined location where to search for a service locator)
    - The service class → DistributedActorWrapper.class (class that provides the distributed service)
- **Discovers a Service Locator**
  - Unicast (specific location is known)
  - Multicast (no location is known)
  - Both
- **Creates and exports the Service**
  - Exports an instance of a proxy class based on the service implementation to the Service Locator
    - This proxy allows to make RMI calls to the implementation
- **Stays alive**
  - Maintains the registration lease with the service locator.
    - The registration of the service has to be renewed.

Server (Discovery and Service Registration)



The Client

- **Prepare for discovery of a Service Locator**
  - ClientServerInteractionManager encapsulates the Jini functionality
  - Calculates the number of servers required (number of actors)
  - Loads various settings as for example unicast locators
- **Discover a Service Locator**
  - Either unicast, multicast or both
- **Looking up Services**
  - ServiceDiscoveryManager, LookupCache → DistributedActorWrapper
- **Filtering Services**
  - Makes sure that the gathered services are alive
    - It can happen that a service has died and it is still registered if the lease has not expired.
  - Checks if there is a sufficient number of services to perform the simulation
- **Map Actors onto Services**
  - Creates a mapping that assigns a server for every actor
- **Calls to the Services (RMI)**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Service Lookup
Service Locator
Service
Proxy
Discovery
Client
Look up Services
Server
Service
Proxy
Client / Server interaction
Java RMI
Service
Implementation
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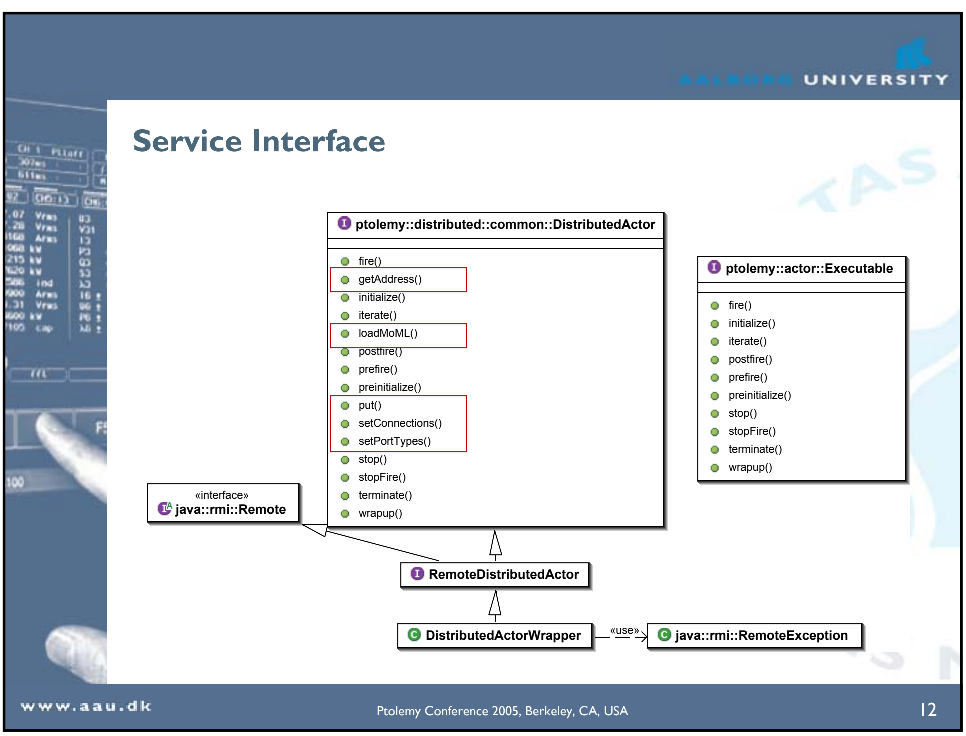
11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Service Interface
ptolemy::distributed::common::DistributedActor
fire()
getAddress()
initialize()
iterate()
loadMoML()
postfire()
prefire()
preinitialize()
put()
setConnections()
setPortTypes()
stop()
stopFire()
terminate()
wrapup()
ptolemy::actor::Executable
fire()
initialize()
iterate()
postfire()
prefire()
preinitialize()
stop()
stopFire()
terminate()
wrapup()
«interface»
java::rmi::Remote
RemoteDistributedActor
DistributedActorWrapper
«use»
java::rmi::RemoteException
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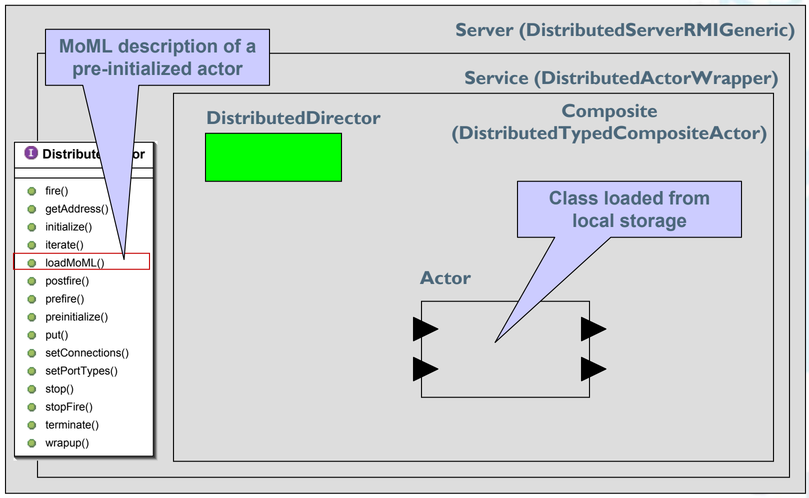
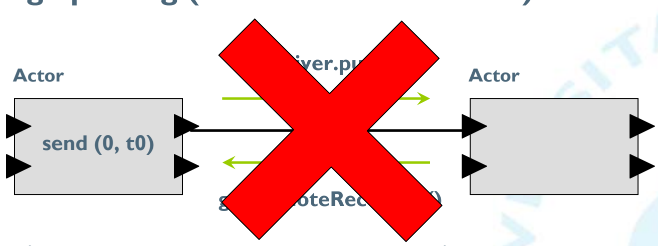
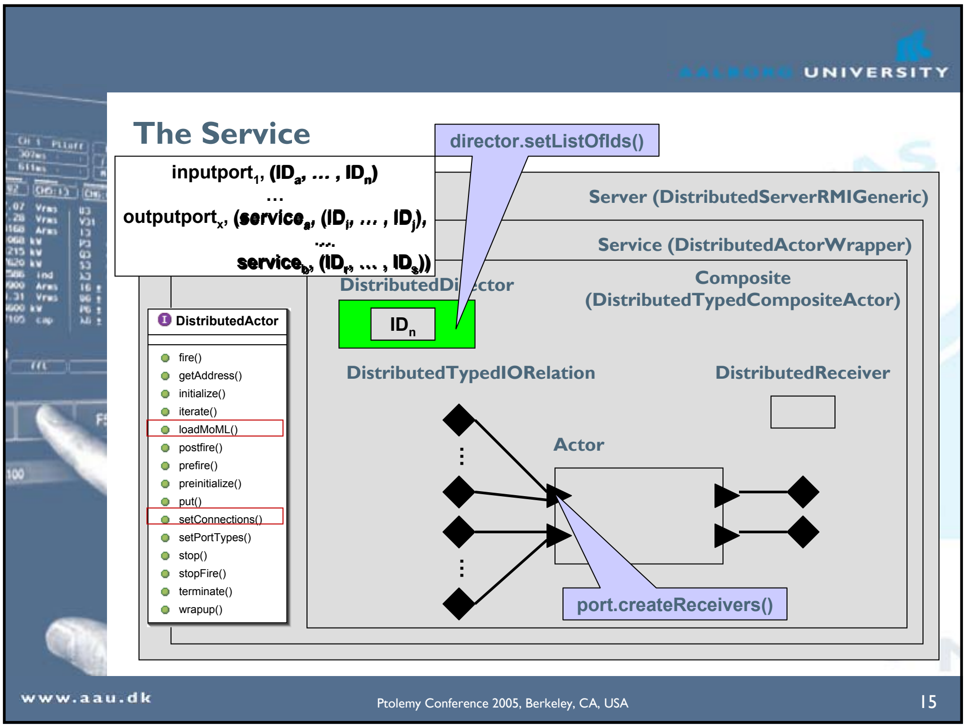
Server and Service



Message passing (Distributed Receivers)



- **Receivers are created at every connected input port to hold tokens for every connection**
- **Two new types of distributed receivers have been created**
  - DistributedSDFReceiver extends SDFReceiver with an unique ID in order to identify Receivers when distributed
  - The DistributedReceiver forwards tokens to remote services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The Service
director.setListOfIds()
inputport1, (IDa, … , IDn)
…
outputportx, (servicea, (IDi, … , IDj),
…
serviceb, (IDr, … , IDs))
Server (DistributedServerRMIGeneric)
Service (DistributedActorWrapper)
DistributedDirector
Composite
(DistributedTypedCompositeActor)
IDn
DistributedActor
fire()
getAddress()
initialize()
iterate()
loadMoML()
postfire()
prefire()
preinitialize()
put()
setConnections()
setPortTypes()
stop()
stopFire()
terminate()
wrapup()
DistributedTypedIORelation
DistributedReceiver
Actor
port.createReceivers()
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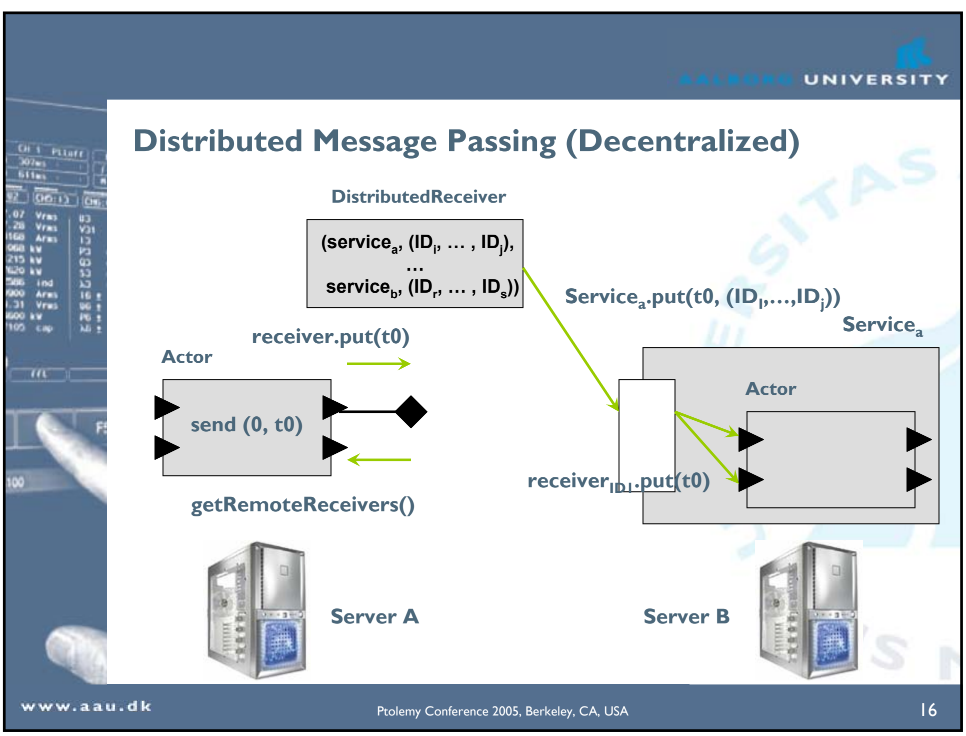
15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Distributed Message Passing (Decentralized)
DistributedReceiver
(servicea, (IDi, … , IDj),
…
serviceb, (IDr, … , IDs))
Servicea.put(t0, (IDi,…,IDj))
Servicea
receiver.put(t0)
Actor
send (0, t0)
Actor
receiverID1.put(t0)
getRemoteReceivers()
Server A
Server B
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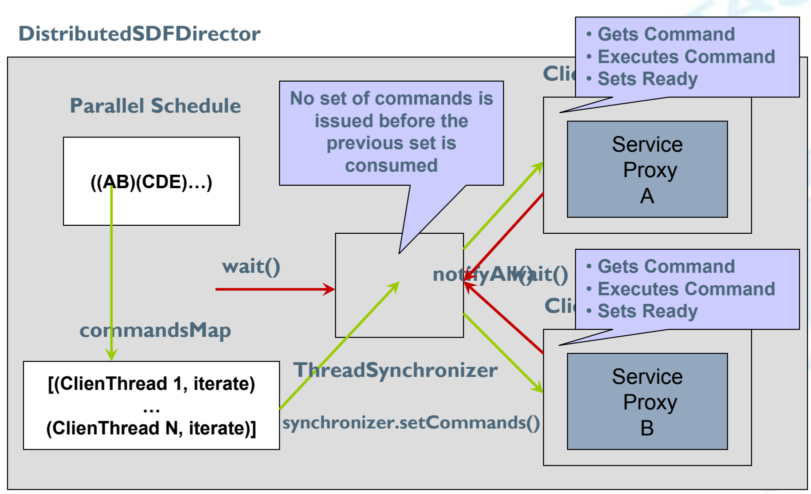
16

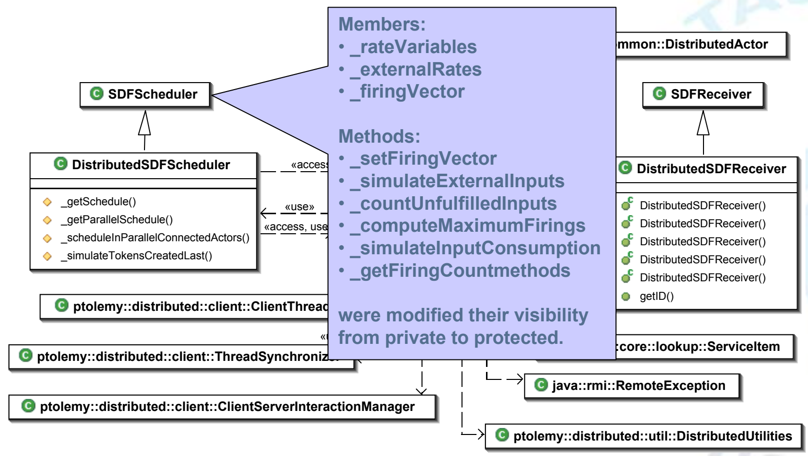
Issuing commands in parallel and synchronization (Client)

- In order to allow parallel execution a Thread (ClientThread) is created to handle calls to different servers in parallel
- These threads prevent the main thread of execution to be blocked by the remote calls to the remote services
- A synchronization mechanism to issue and access commands in parallel is provided by ThreadSynchronizer
- Centralized

Issuing commands in parallel and synchronization



Client's Software Architecture



Software Packages

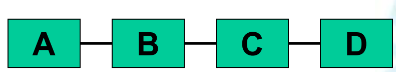
- **ptolemy.distributed.actor**
  - DistributedDirector, DistributedReceiver, DistributedTypedCompositeActor, DistributedTypedIORelation
- **ptolemy.distributed.actor.lib**
  - Library of distributed actors
- **ptolemy.distributed.client**
  - ClientServerInteractionManager, ClientThread, ThreadSynchronizer
- **ptolemy.distributed.common**
  - DistributedActor Interface
- **ptolemy.distributed.config**
  - Jini config files
- **ptolemy.distributed.rmi (Server classes)**
  - DistributedActorWrapper, DistributedServerRMIGeneric, RemoteDistributedActor
- **ptolemy.distributed.util**
  - DistributedUtilities
- **ptolemy.domains.sdf.kernel**
  - DistributedSDFDirector, Scheduler & Receiver

Further Work

- **Optimization of the initialization phase**
  - Reduce to one single call for each actor
  - Perform initialization in parallel
- **Security + Robustness**
- **Jini -> Jxta**
- **Implement distributed versions of other domains**
- **Allow for remote loading of classes as opposed to local loading**
- **Pipelining**

Pipelining

- **To increase parallelism**
  - Can be applied to models without loops



Buffering Phase:
((A))
((A B))
((A B C))

Fully Parallel:
((A B C D))

Conclusions

- The Distributed-SDF domain automates distributed simulation of SDF models.
- It does not modify the existing architecture, just extends it
- Implements common features that can be reutilized to make distributed versions of other domains
- Allows to speedup simulations (specially for models where the computation cost > communication cost)
- Allows for larger models by distributing the memory load