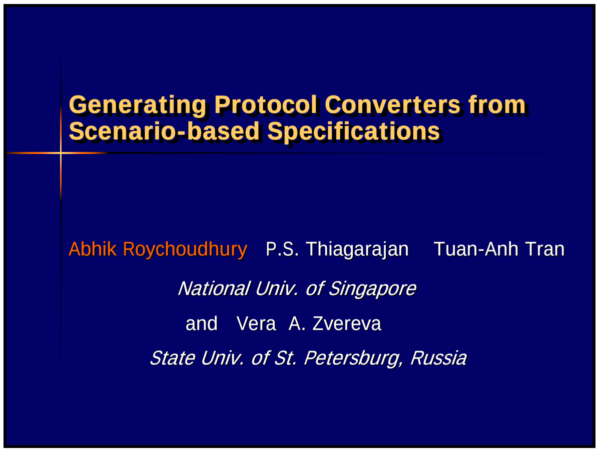

Generating Protocol Converters from Scenario-based Specifications

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National Univ. of Singapore

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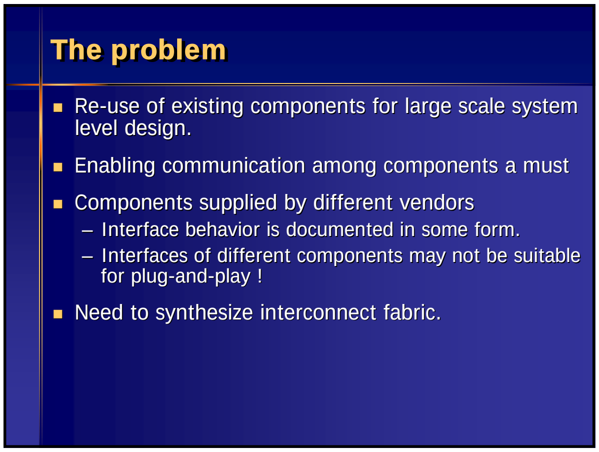
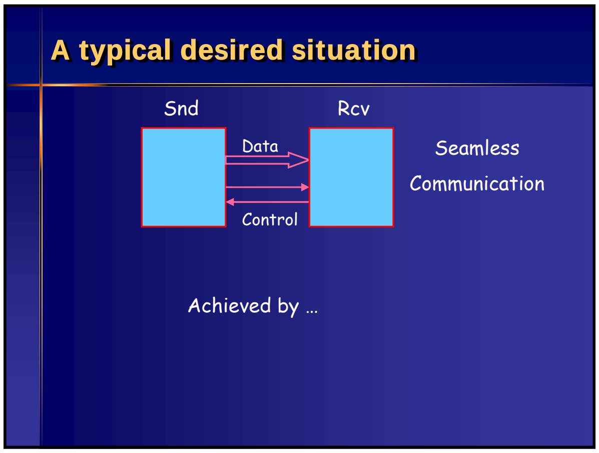


The problem

- Re-use of existing components for large scale system level design.
- Enabling communication among components a must
- Components supplied by different vendors
  - Interface behavior is documented in some form.
  - Interfaces of different components may not be suitable for plug-and-play !
- Need to synthesize interconnect fabric.



A typical desired situation

Snd

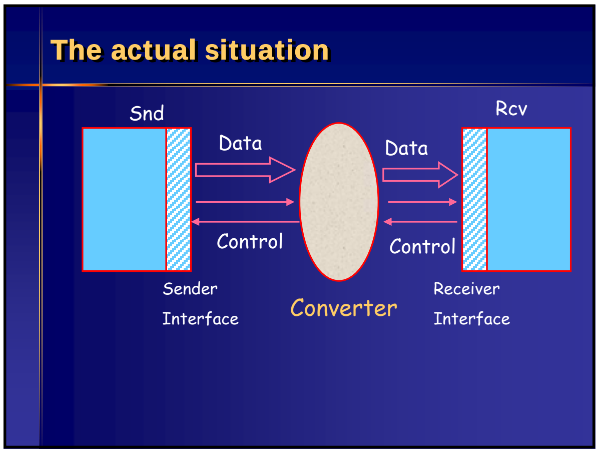
Rcv

Data

Control

Seamless Communication

Achieved by …



The actual situation

Snd

Rcv

Data

Data

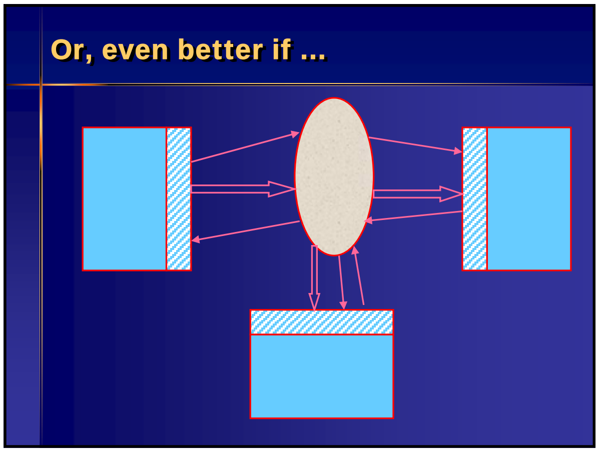
Control

Control

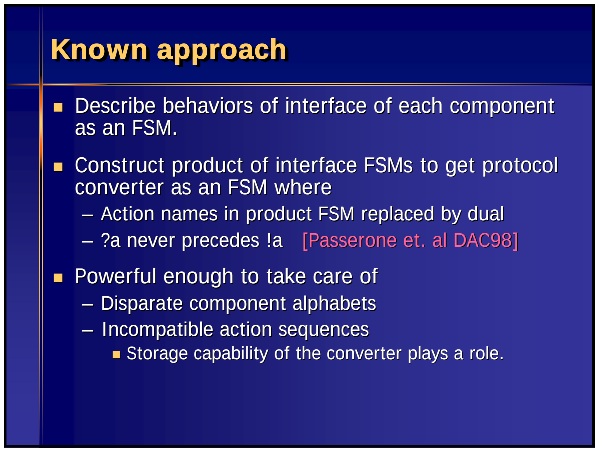
Sender Interface

Converter

Receiver Interface

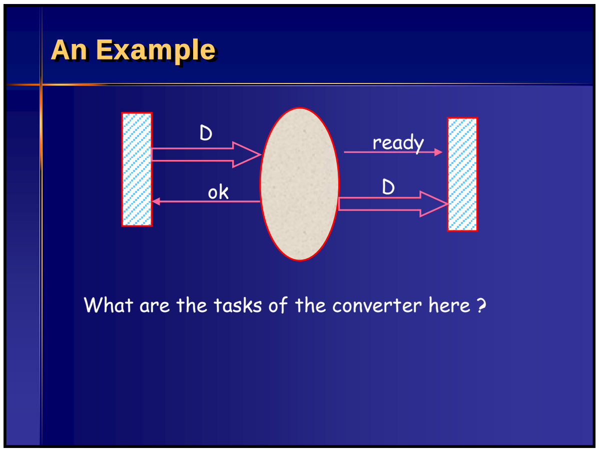


Or, even better if …



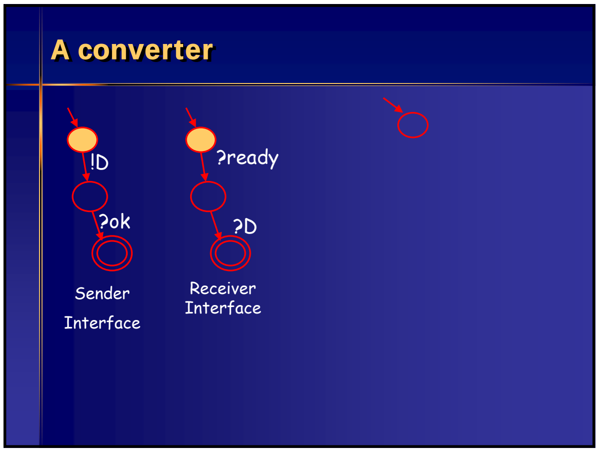
Known approach

- Describe behaviors of interface of each component as an FSM.
- Construct product of interface FSMs to get protocol converter as an FSM where
  - Action names in product FSM replaced by dual
  - ?a never precedes !a   [Passerone et. al DAC98]
- Powerful enough to take care of
  - Disparate component alphabets
  - Incompatible action sequences
    - Storage capability of the converter plays a role.

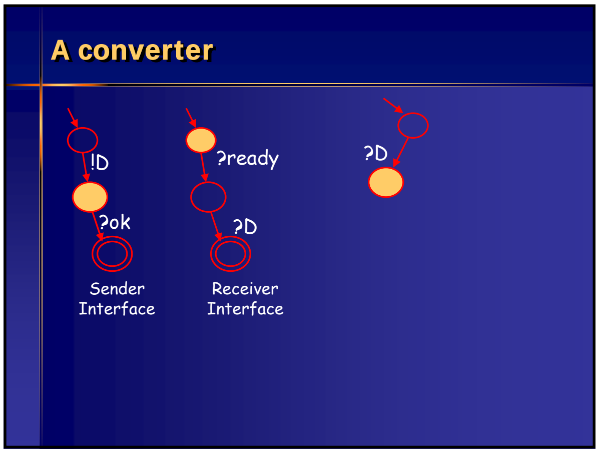


An Example

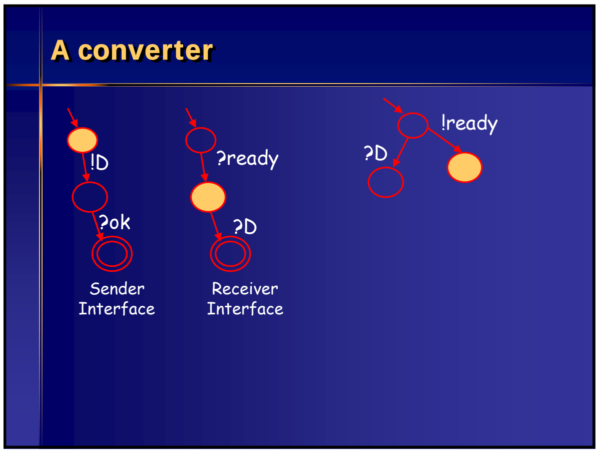
What are the tasks of the converter here ?



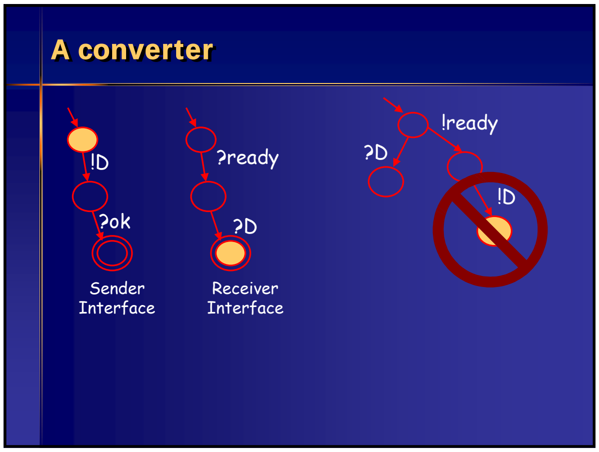
A converter



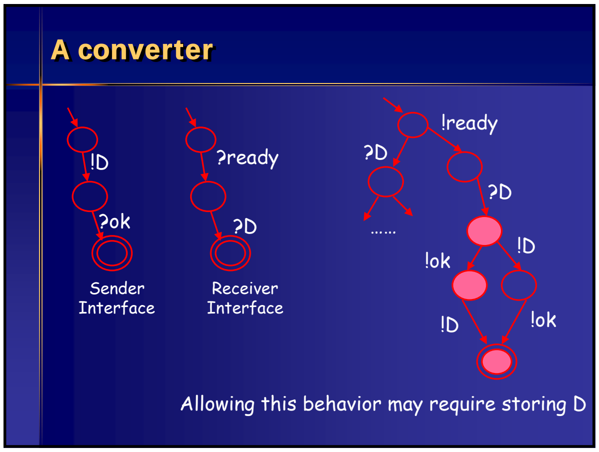
A converter



A converter



A converter



A converter

Allowing this behavior may require storing D

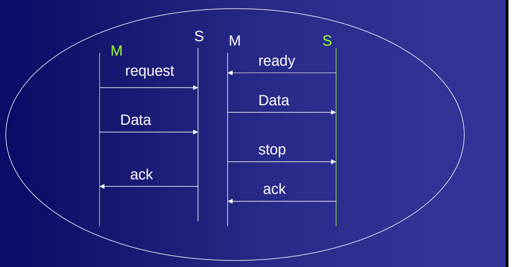
Is this enough ?

- The example protocols refer to only one “episode” between two components
  - Transfer of data D
- Extensions:
  - Protocols among multiple components
    - Take the product of all the interface FSMs
  - Protocols spanning several episodes
    - Runs of infinite length in each native protocol
    - All episodes combined in FSM [Passerone et. al. ‘02]
- Can we think about the problem per-episode ?

Protocol conversion, but

- … an episode at a time.
  - Getting a per-episode inter-component description from the interface of each component
    - Flow between episodes captured as a graph
  - Using the inter-component description for
    - Protocol conversion of a single episode
    - Protocol conversion for a graph of episodes
- In this paper
  - The protocol conversion problem.

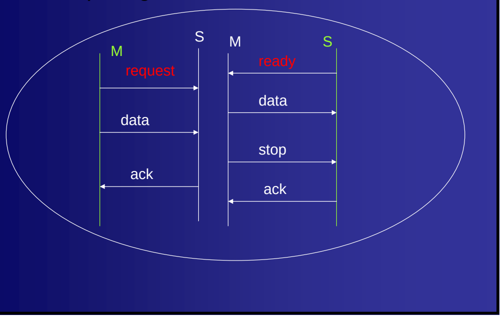
Describing an episode



Collection of Message Sequence Charts (MSCs)

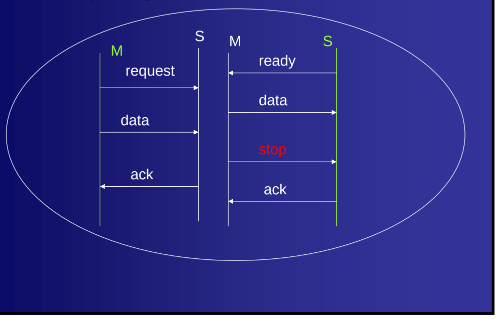
Converter for an episode

- Consume input signals



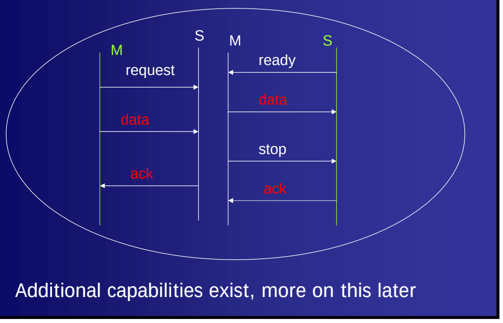
Converter for an episode

- Produce output signals

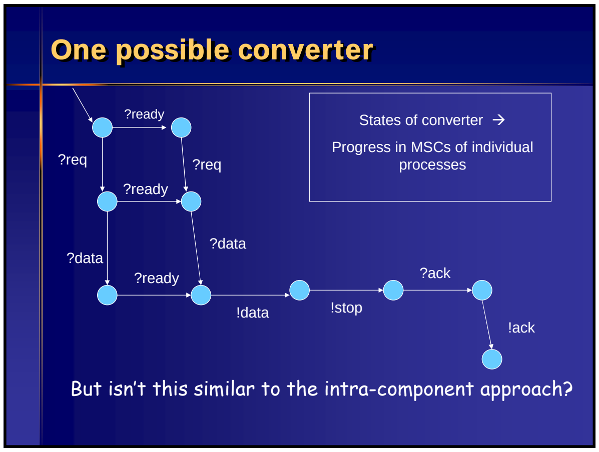


Converter for an episode

- Receive and Forward Shared signals



Additional capabilities exist, more on this later

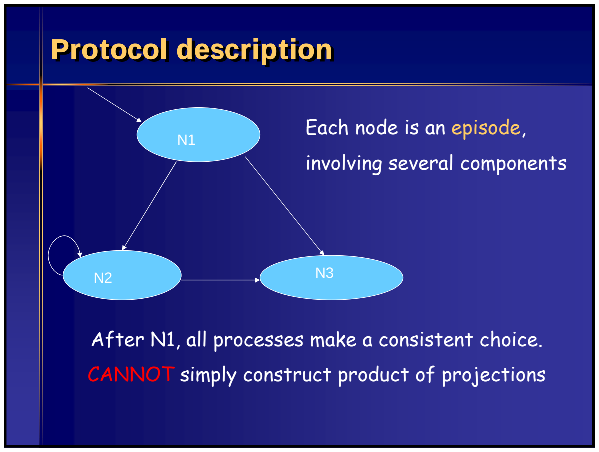


One possible converter

States of converter →

Progress in MSCs of individual processes

But isn't this similar to the intra-component approach?

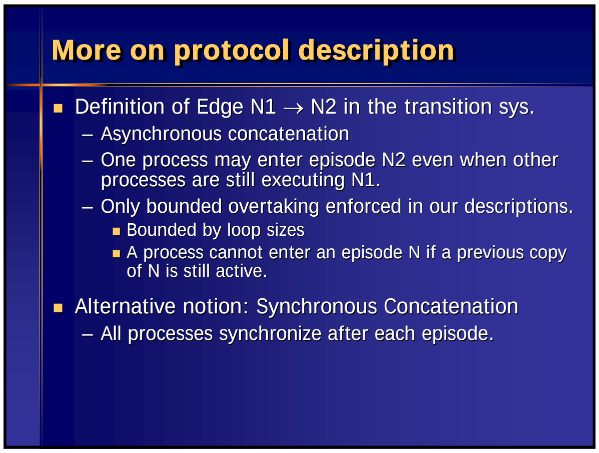


Protocol description

Each node is an episode, involving several components

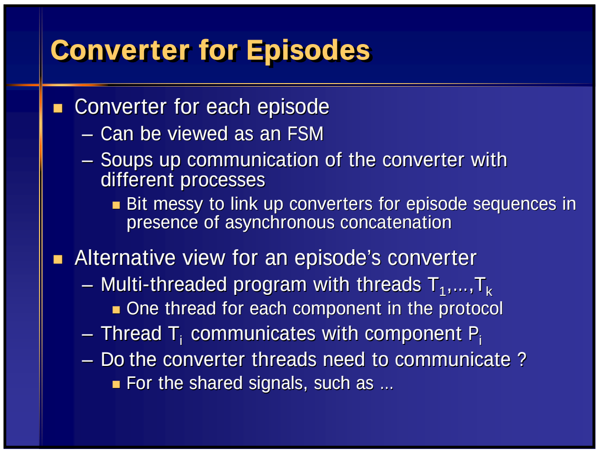
After N1, all processes make a consistent choice.

CANNOT simply construct product of projections



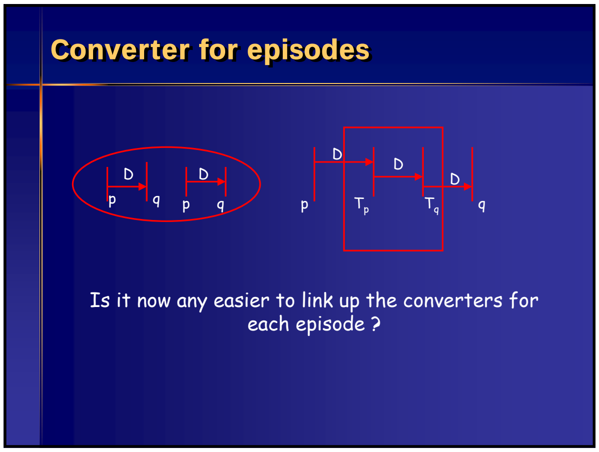
More on protocol description

- Definition of Edge N1 → N2 in the transition sys.
  - Asynchronous concatenation
  - One process may enter episode N2 even when other processes are still executing N1.
  - Only bounded overtaking enforced in our descriptions.
    - Bounded by loop sizes
    - A process cannot enter an episode N if a previous copy of N is still active.
- Alternative notion: Synchronous Concatenation
  - All processes synchronize after each episode.



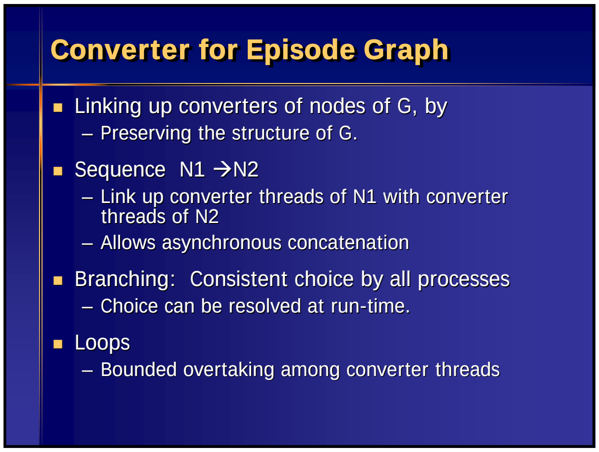
Converter for Episodes

- Converter for each episode
  - Can be viewed as an FSM
  - Soups up communication of the converter with different processes
    - Bit messy to link up converters for episode sequences in presence of asynchronous concatenation
- Alternative view for an episode's converter
  - Multi-threaded program with threads $T_1,\ldots,T_k$
    - One thread for each component in the protocol
  - Thread T_i communicates with component P_i
  - Do the converter threads need to communicate ?
    - For the shared signals, such as …



Converter for episodes

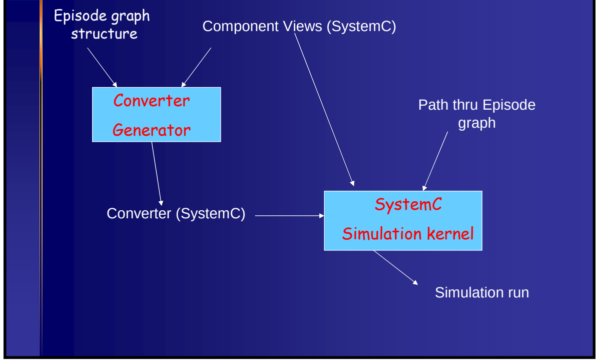
Is it now any easier to link up the converters for each episode ?



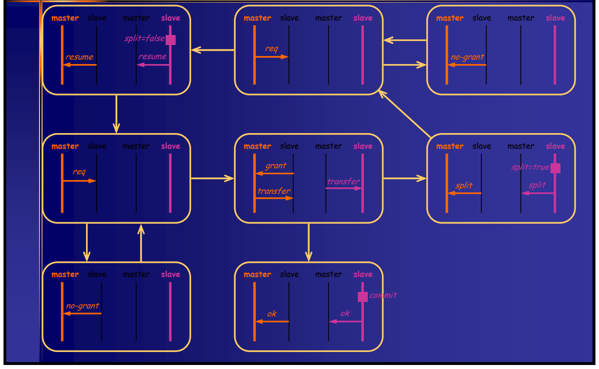
Converter for Episode Graph

- Linking up converters of nodes of G, by
  - Preserving the structure of G.
- Sequence N1 →N2
  - Link up converter threads of N1 with converter threads of N2
  - Allows asynchronous concatenation
- Branching: Consistent choice by all processes
  - Choice can be resolved at run-time.
- Loops
  - Bounded overtaking among converter threads

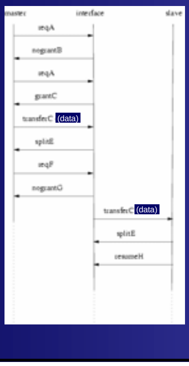
Implementation



Example : Split Transfers



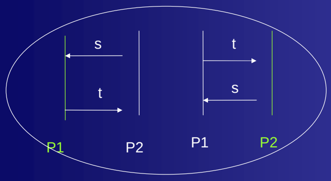
Sample simulation trace



Our work

- How to describe
  - Inter-component interactions and their episodes
- How to synthesize
  - Component interfaces/converters
    - Interface for one episode
    - Interface for entire episode graph
  - Clock sensitivities and timers (handle timeouts etc)
    - Brings in synchronicity into our asynch. description
- Modeling and converter synthesis for various features of System-on-Chip Bus protocols.
- Can we always synthesize converters ?

More aggressive converters



Speculatively generate shared signals even before they are received – integrated into our impl.

But, cannot speculate on data values
s, t could be data signals

Future Work

- Extensions to converter capabilities
  - Data formatting (chopping/merging packets)
- Synthesizing the episodes and episode graph from the SystemC description of component interface
  - SystemC → Inter-component models → SystemC
  - Currently looking at conformity of a given episode graph with SystemC description of interfaces .