Coordinating Data-Parallel **SAC** Programs with **S-Net**

Sven-Bodo Scholz
Clemens Grelck and Alex Shafarenko

Compiler Technology and Computer Architecture Group
University of Hertfordshire, UK

HIPS-ToPMoDRS,
26.March 2007, Long Beach

www.aether-ist.org

SAC in a nutshell

- generic array programming
- purely functional
- no-frills
- aggressive program optimisation
- sequential performance competitive with FORTRAN77
- generation of multi-threaded code without annotations

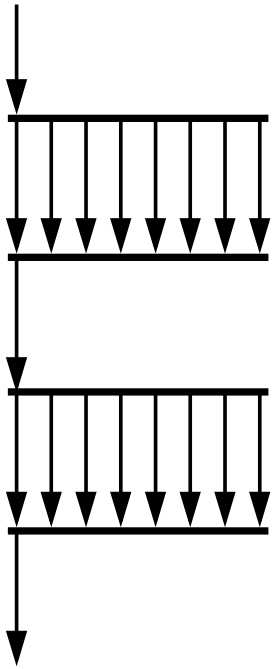
For details see www.sac-home.org

Exploitation of Data-Parallelism in **SAC**

- hinges on our data-parallel construct, the With-Loop
- all our array operations are defined by these
- granularity control by
  - array size inference
  - several fusion techniques
- architecture specific code generation
- POSIX-threads for SMPs
- taylor-made memory management
- almost linear speedups for examples such as NAS-benchmarks

So what is the catch??

Our compiler maps all concurrency into one Concurrency pattern:



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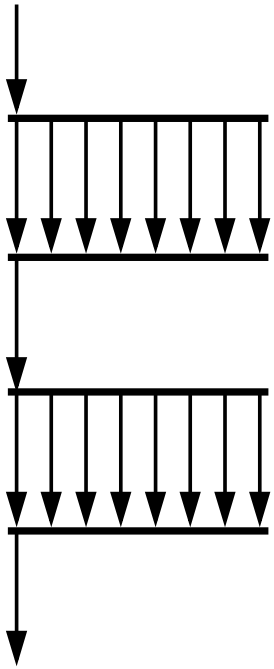
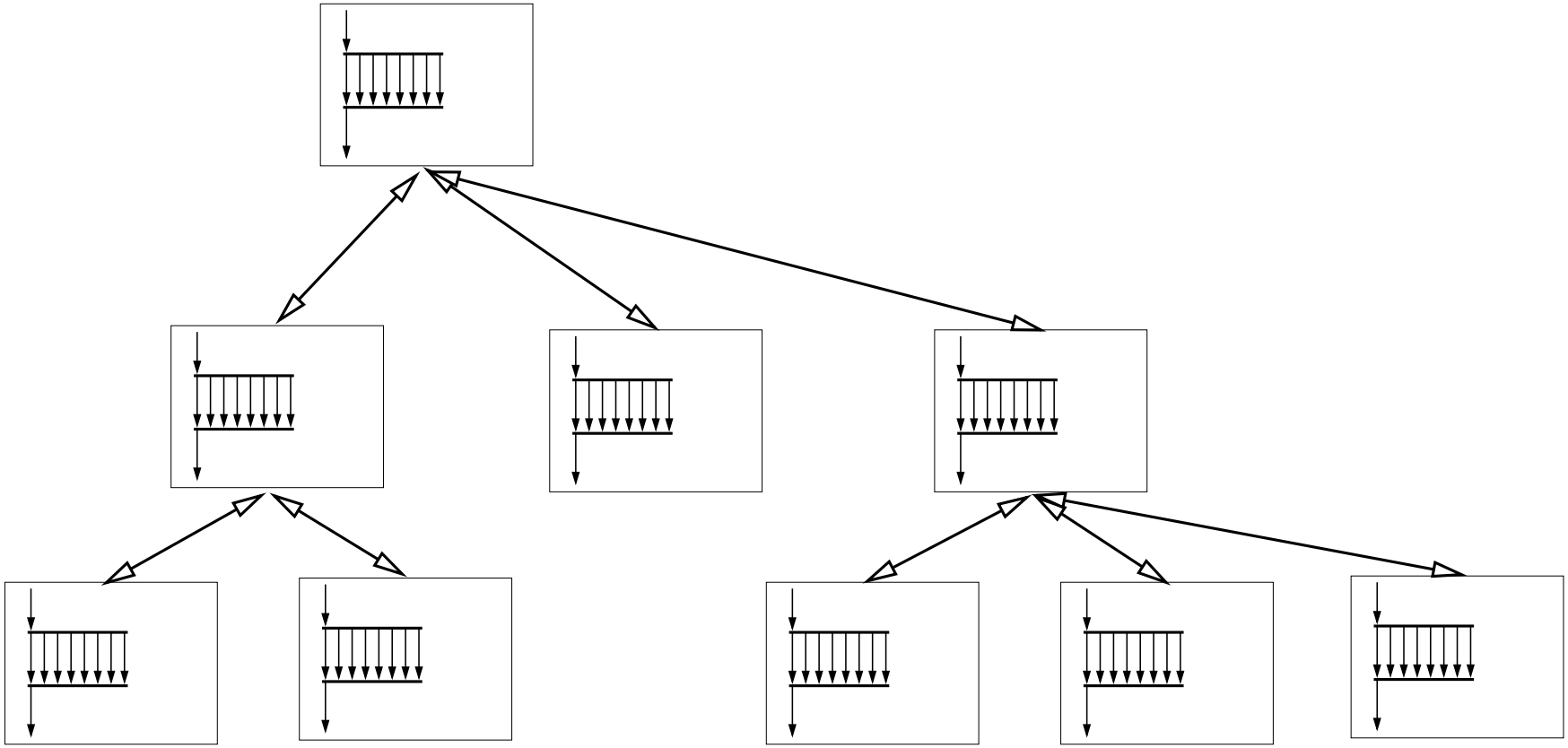


if our application cannot be mapped on this pattern, we cannot exploit its concurrency!

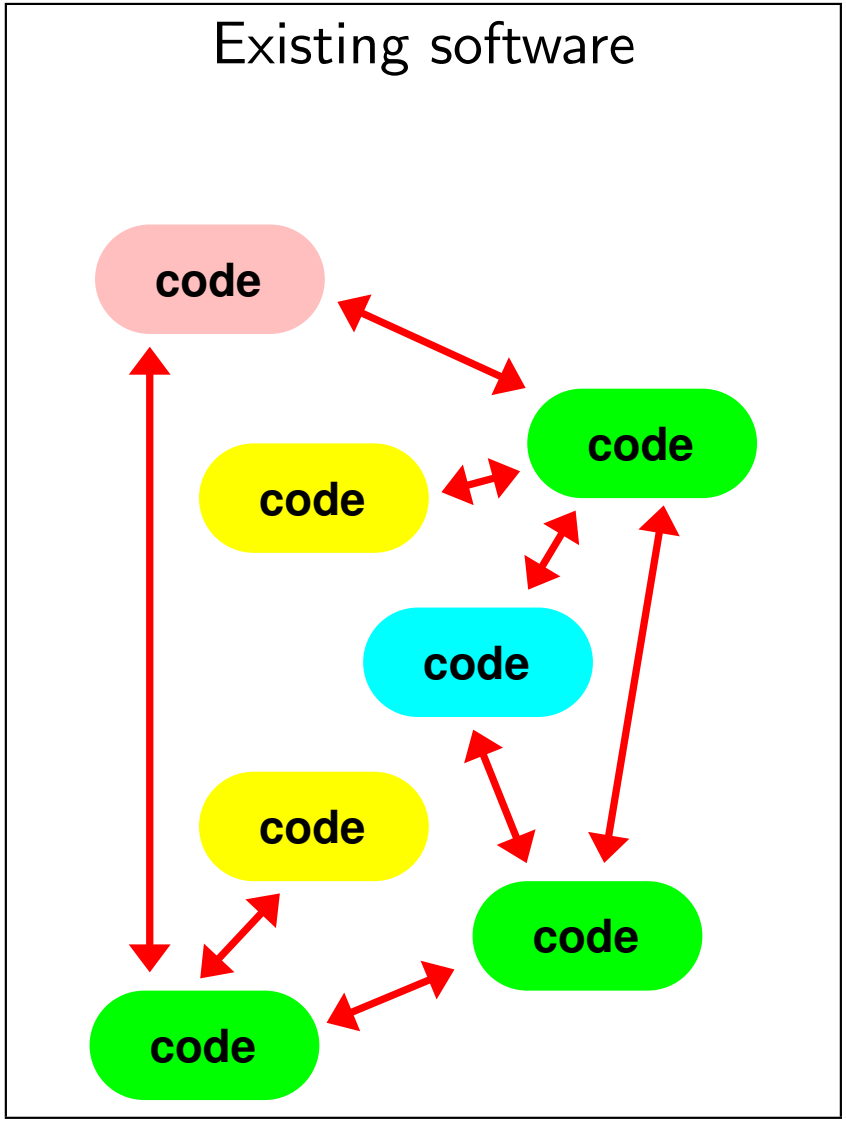
An example: Search Algorithms



Our Approach: **S-Net**

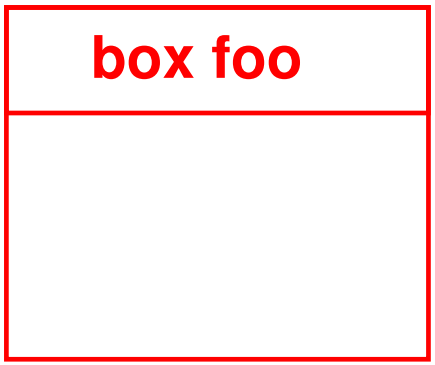
S-Net:

- asynchronous component framework
- functional stream processing
- pure coordination language
- dynamic network creation
- orthogonal to the box language



S-Net at a Glance

- central construct: box
  wraps existing code



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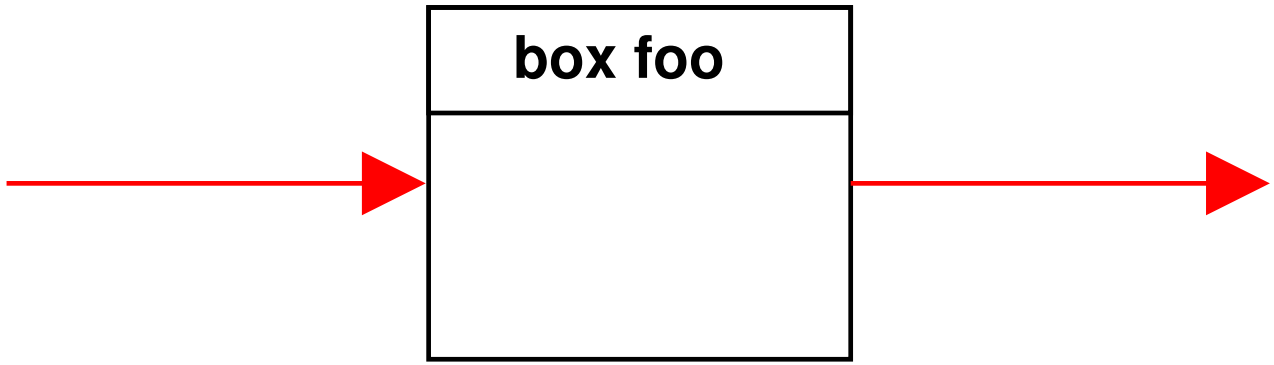

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- streams transport records:
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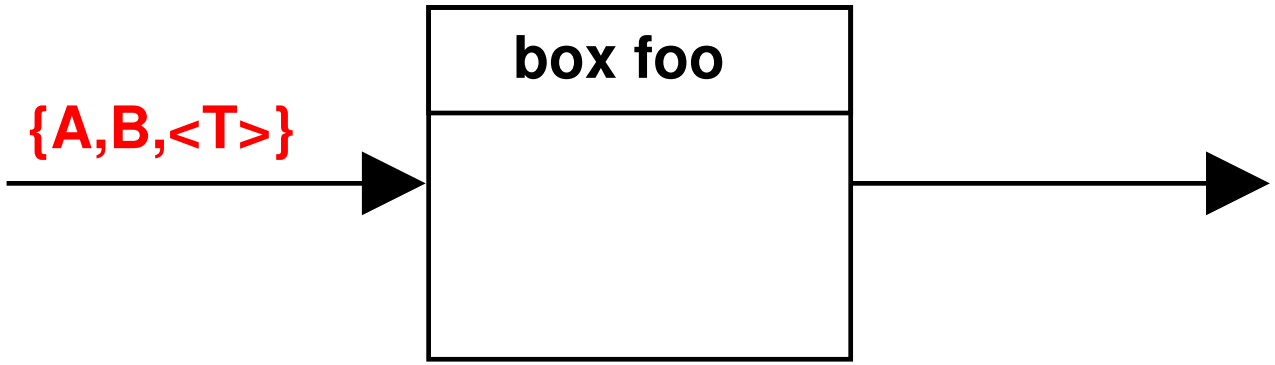
  - opaque value fields
  - integer-valued tag fields



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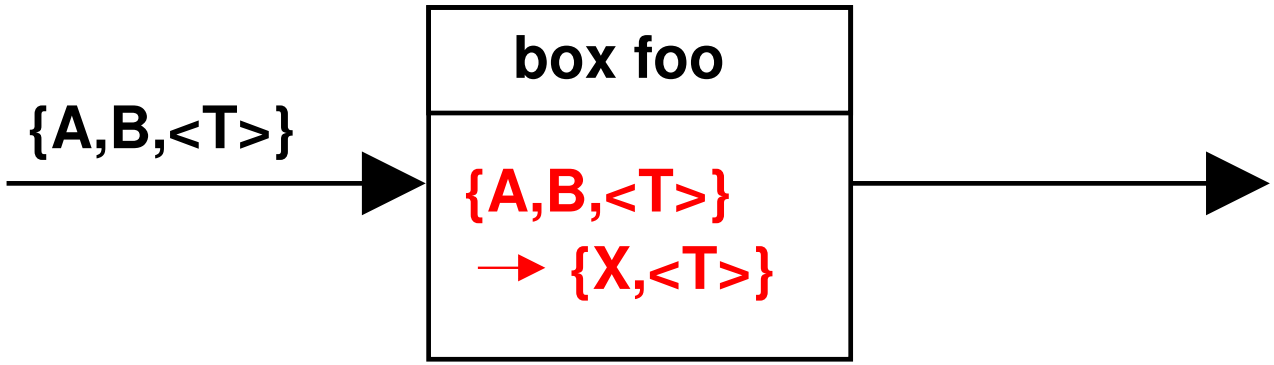

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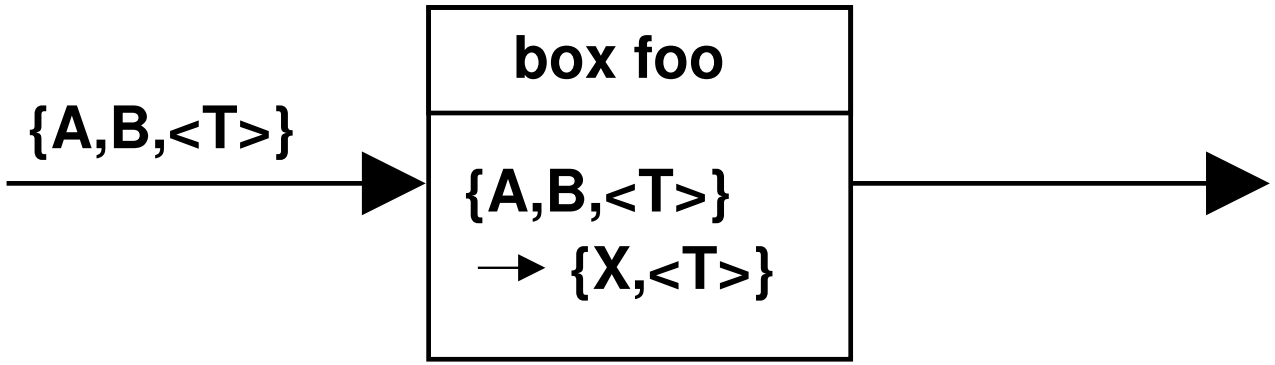

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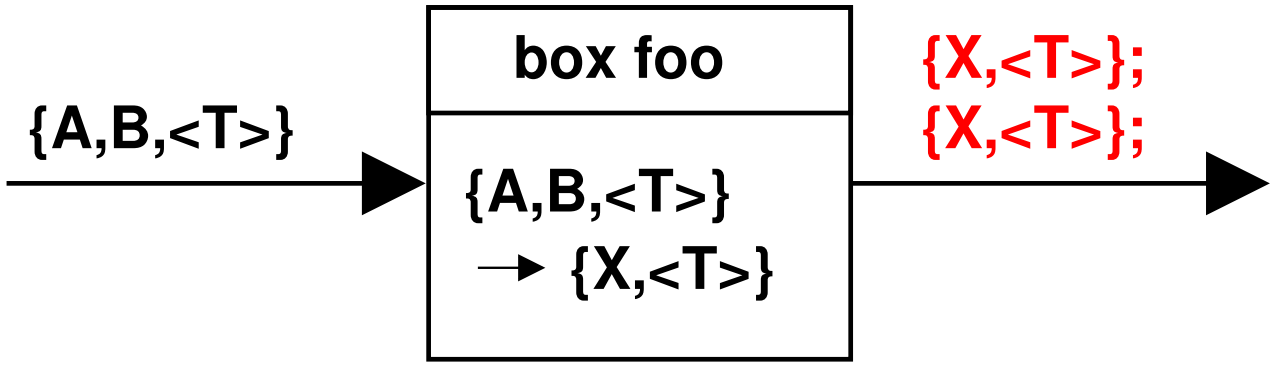
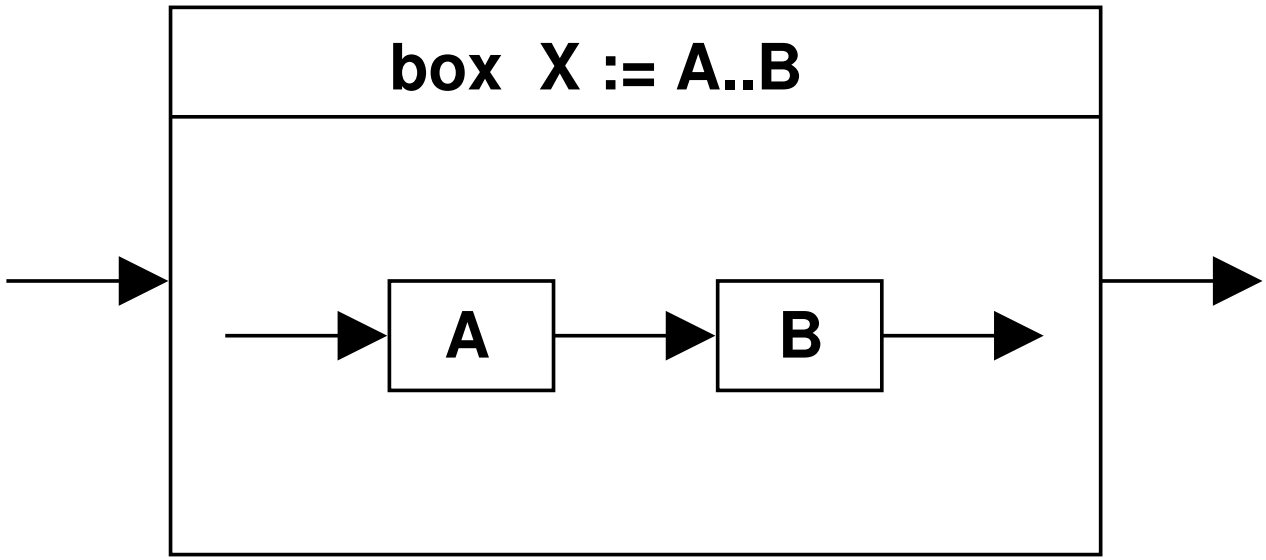
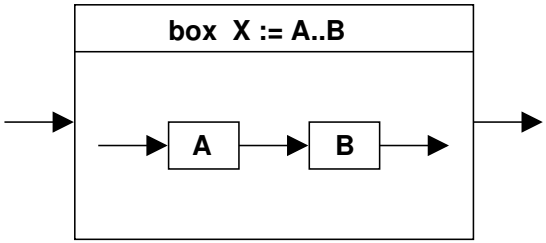
- behaviour defined in box language, not **S-Net**
- box maps single input record to stream of output records

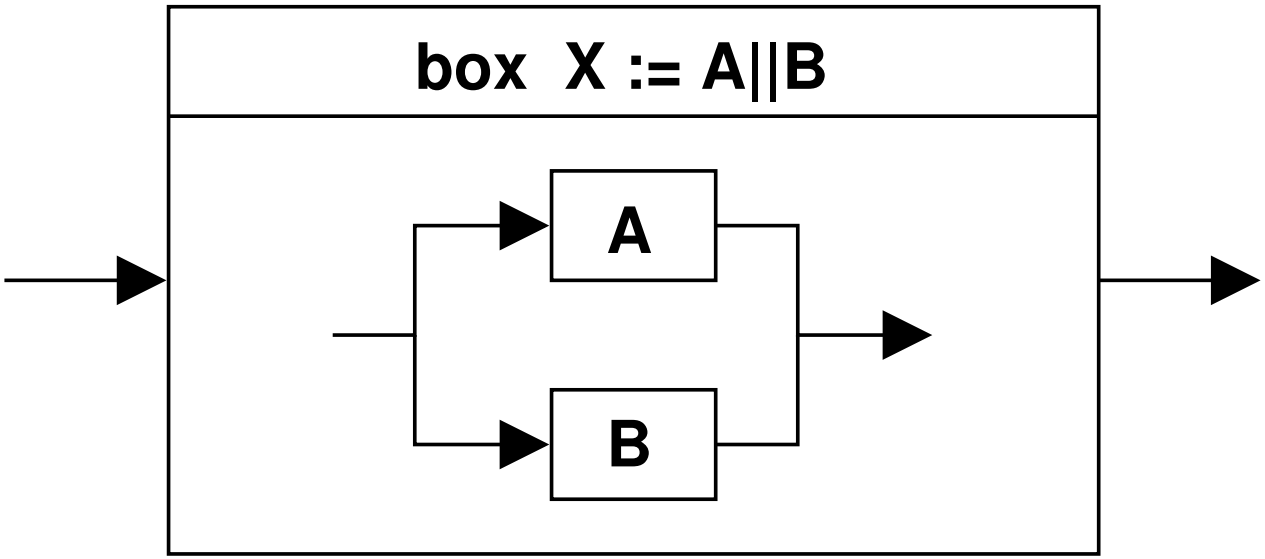


Network Combinators: Serial

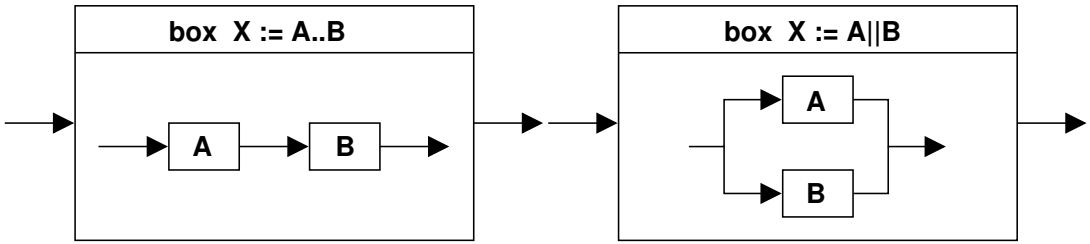


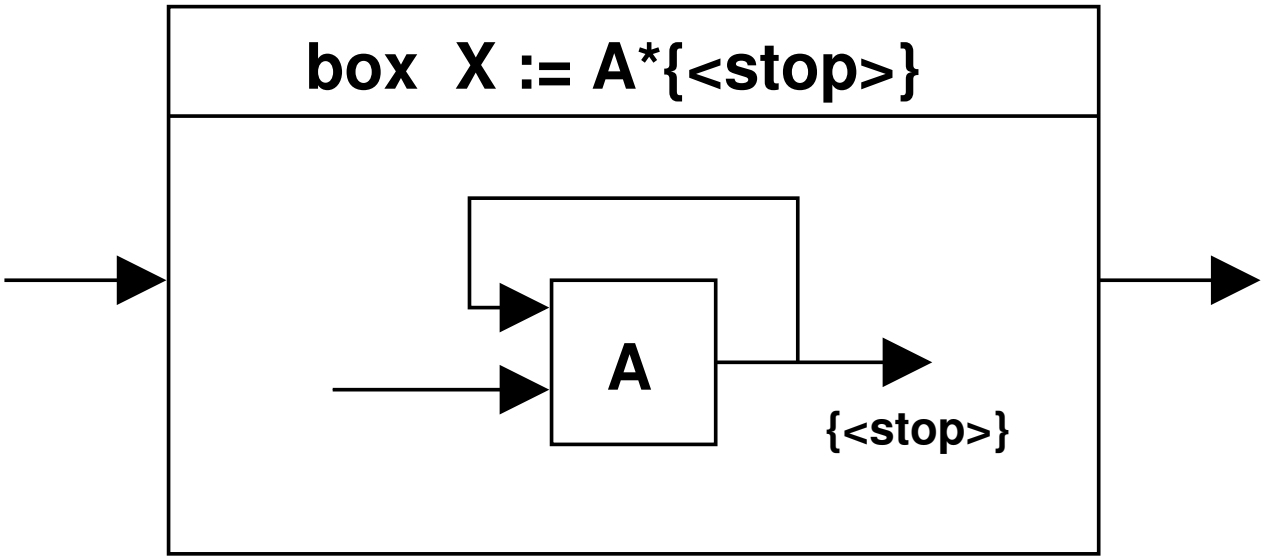
Network Combinators: Choice



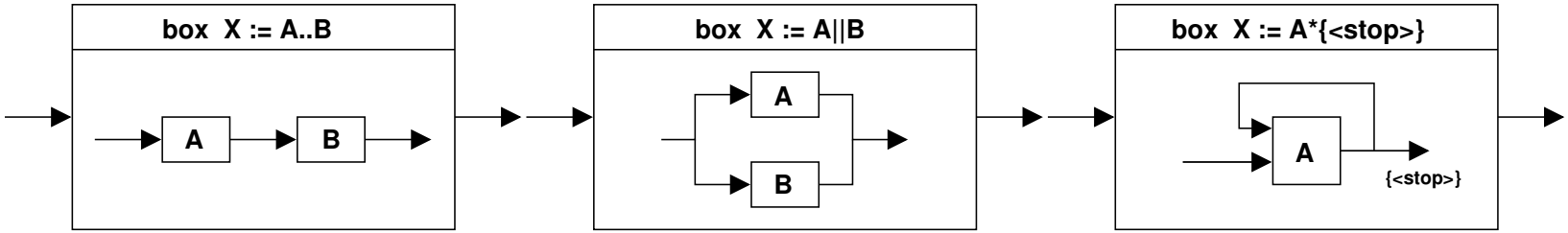


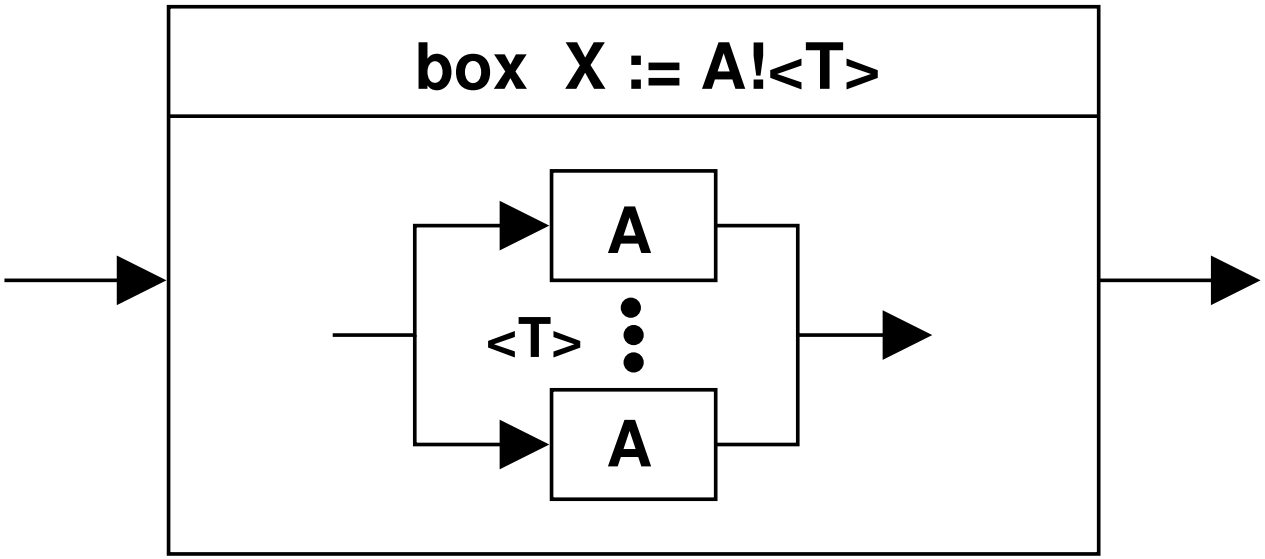
Network Combinators: Serial Replication



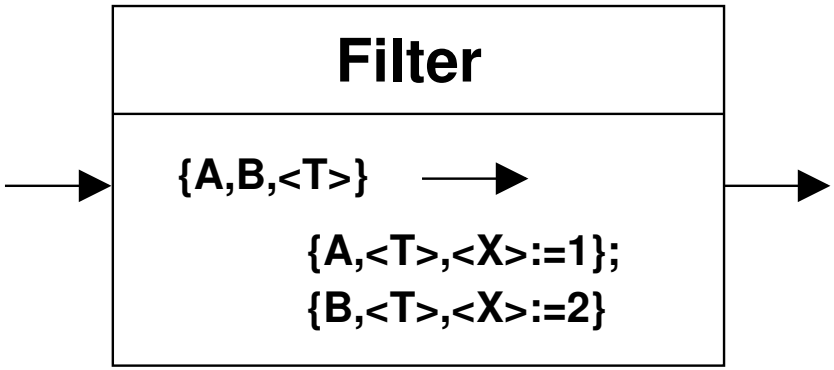


Network Combinators: Index Split





Primitive Boxes: Filter and Sync



housekeeping:

- eliminate record fields
- duplicate record fields
- add tags
- manipulate tag values
- ...

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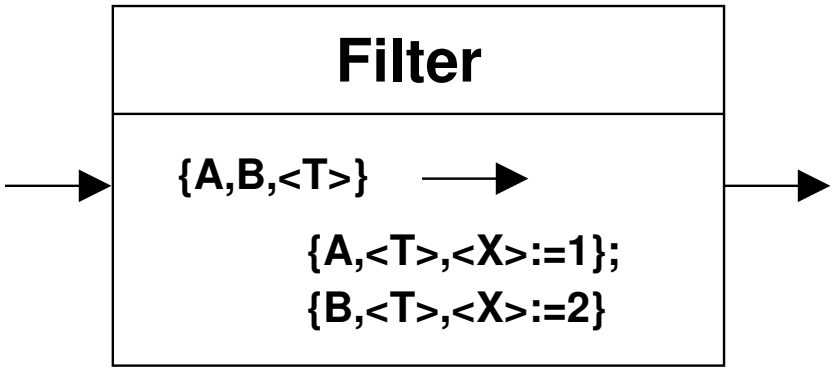
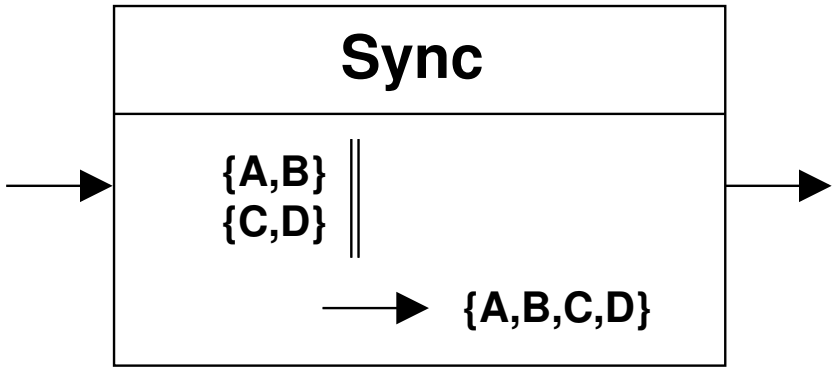




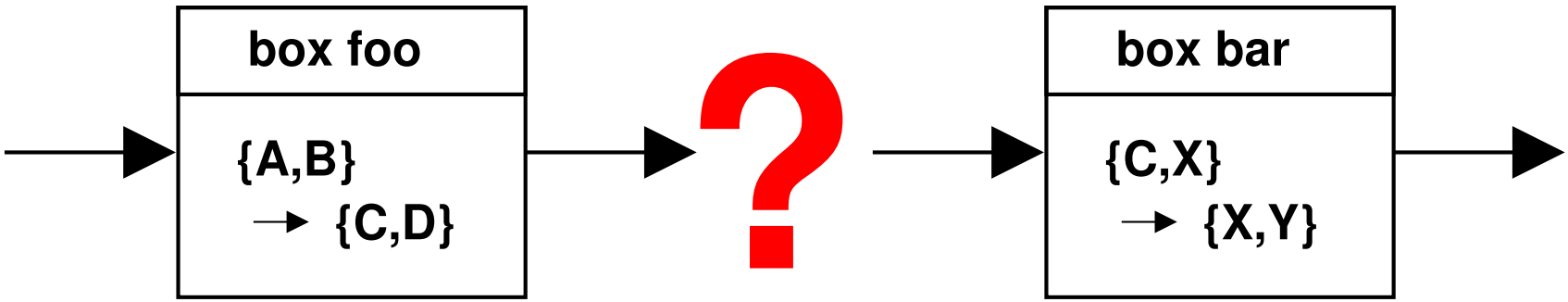
housekeeping:

- eliminate record fields
- duplicate record fields
- add tags
- manipulate tag values
- ...

synchronisation:

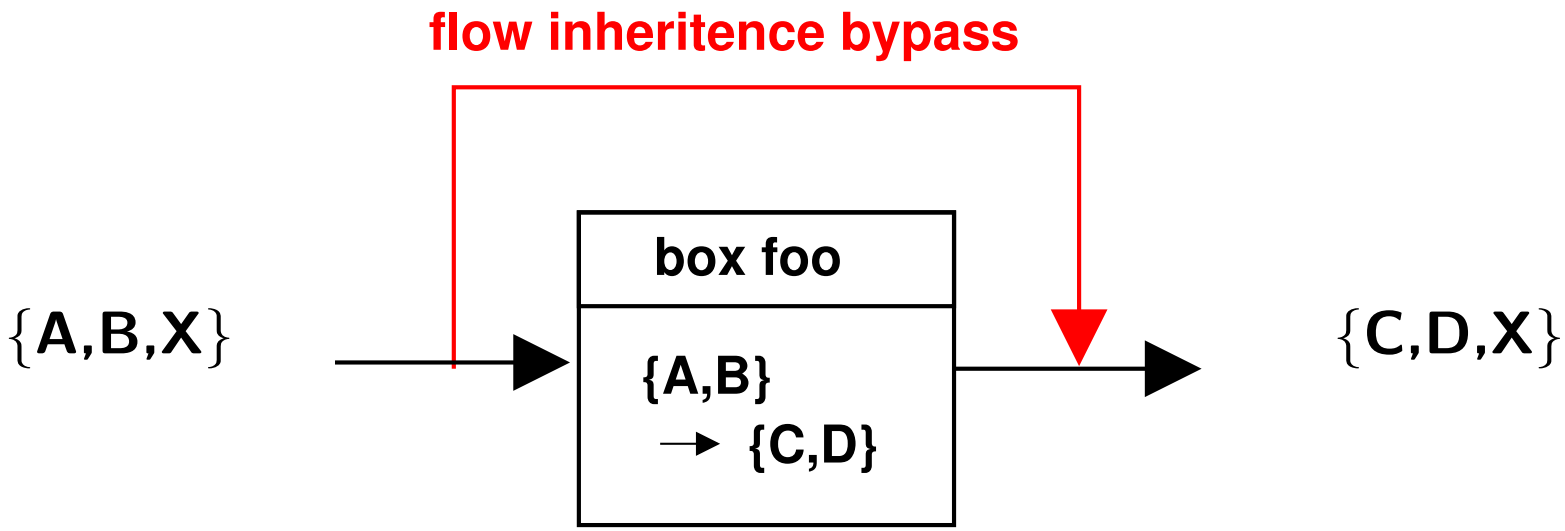
- keep record that matches pattern
- all patterns matched: release merged records
- pattern already matched: pass through

Problem: Incompatible Boxes



- Box code typically designed in isolation.
- Interfaces only partially overlap.
- Network composition unfeasible in practice?

Solution: Flow Inheritence



- Any "unwanted" field is bypassed to output channel
- and is attached to any record produced in response.

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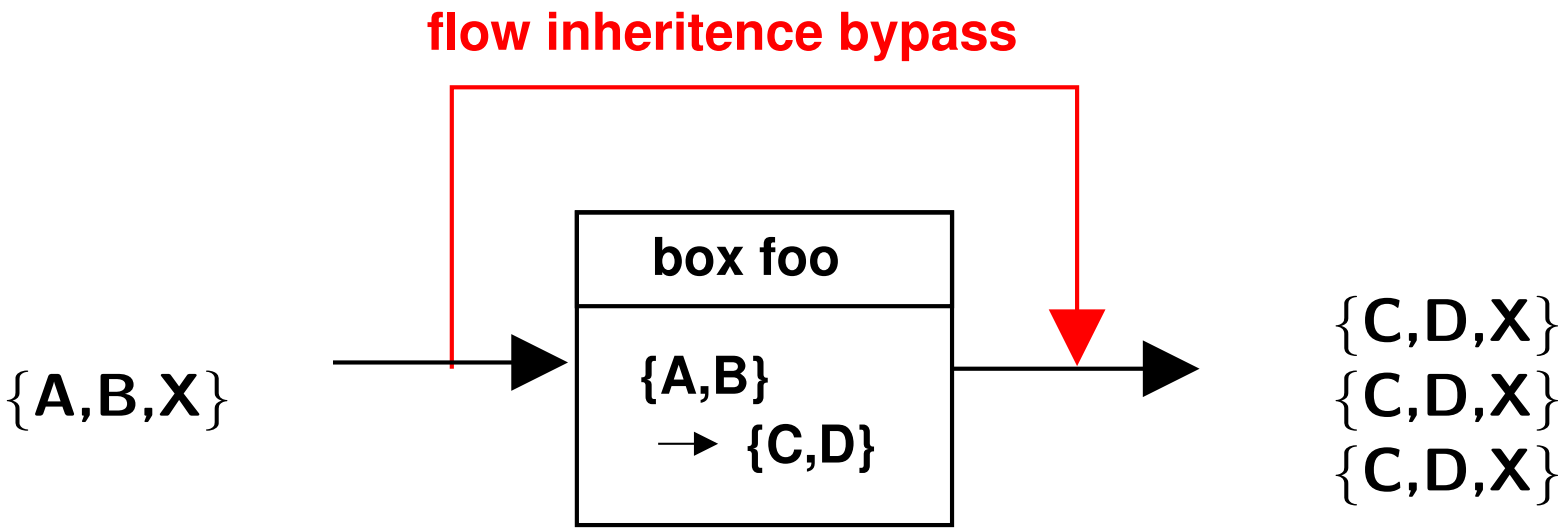

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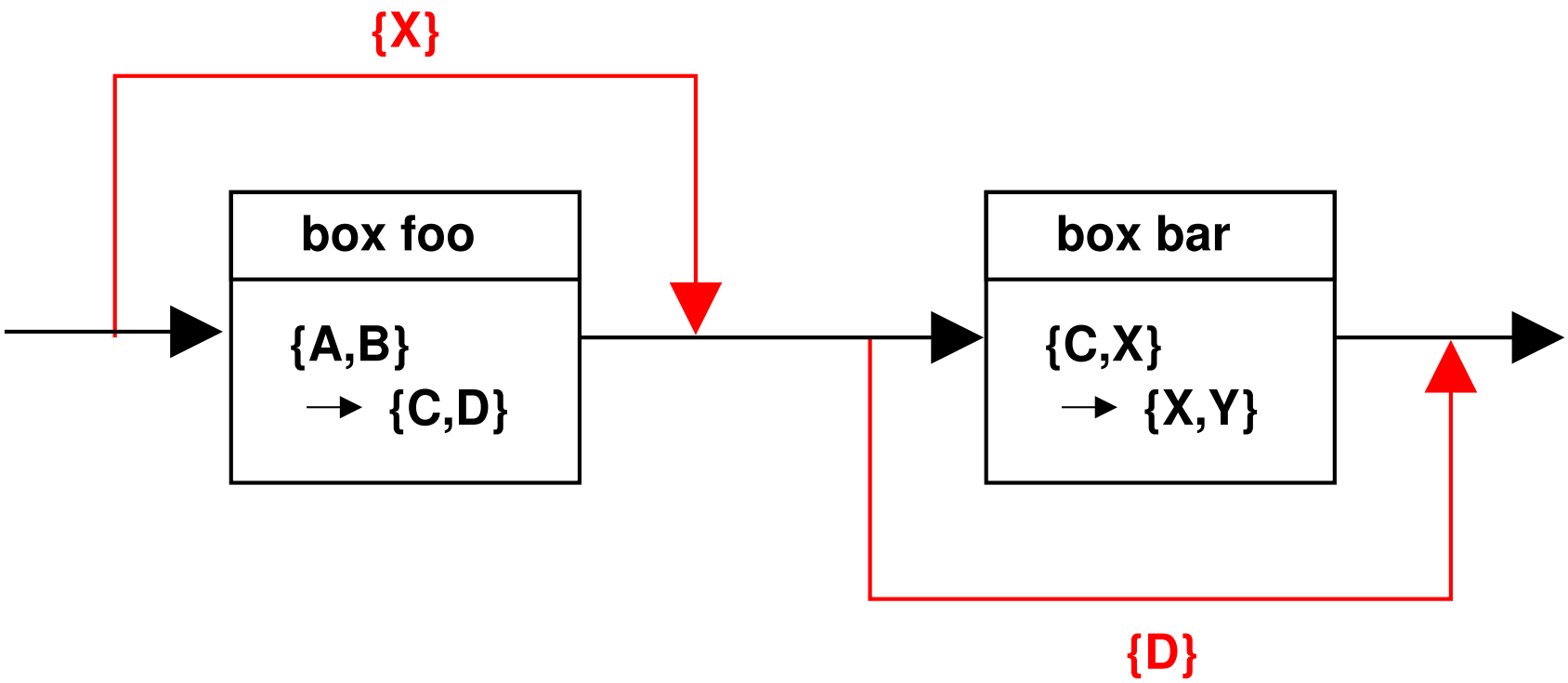
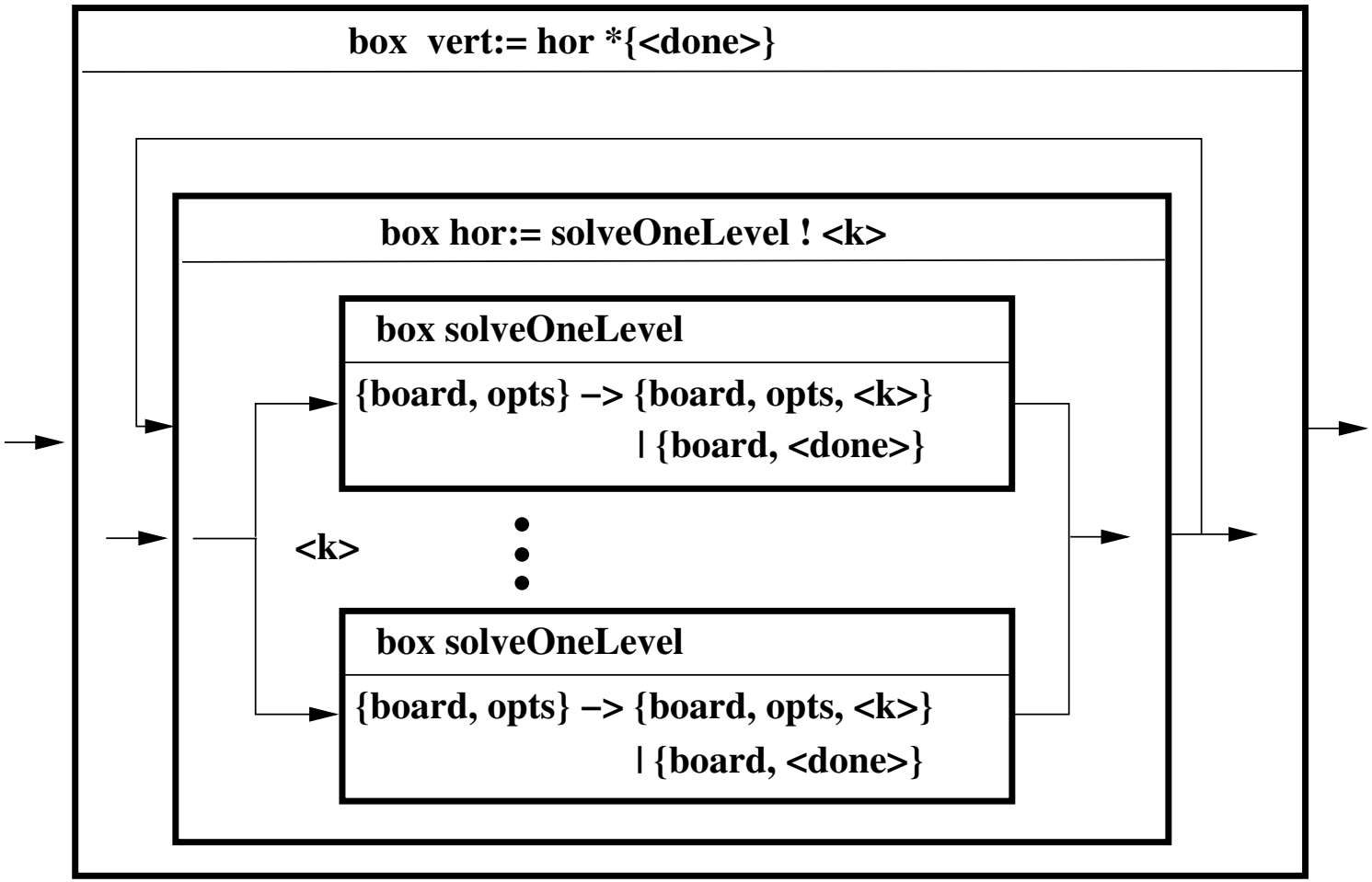
Flow Inheritence: Enabling Network Combination



- Flow inheritence is the key to network glue.

How to apply this to our problem?



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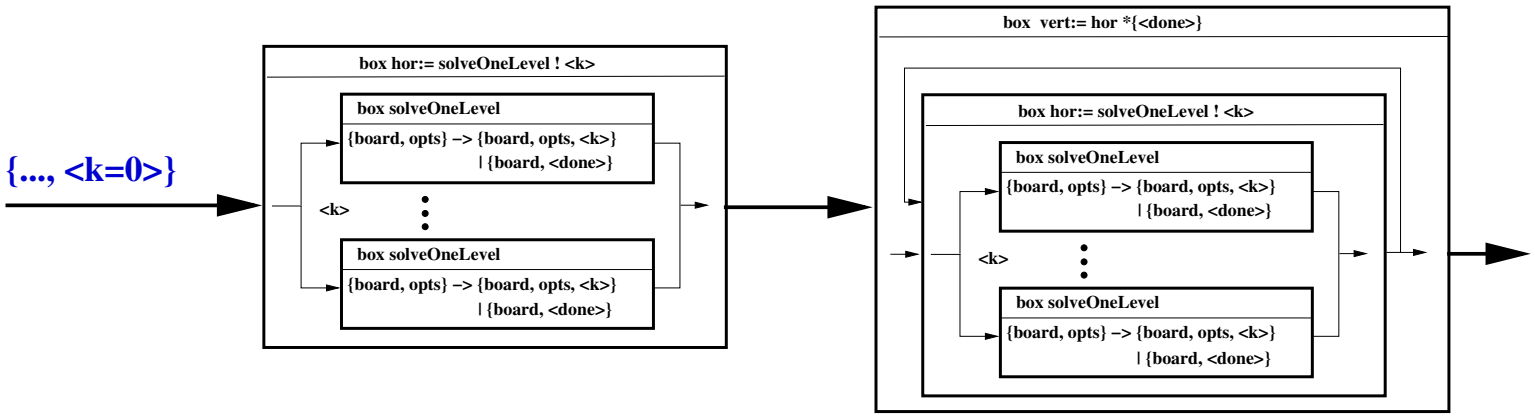

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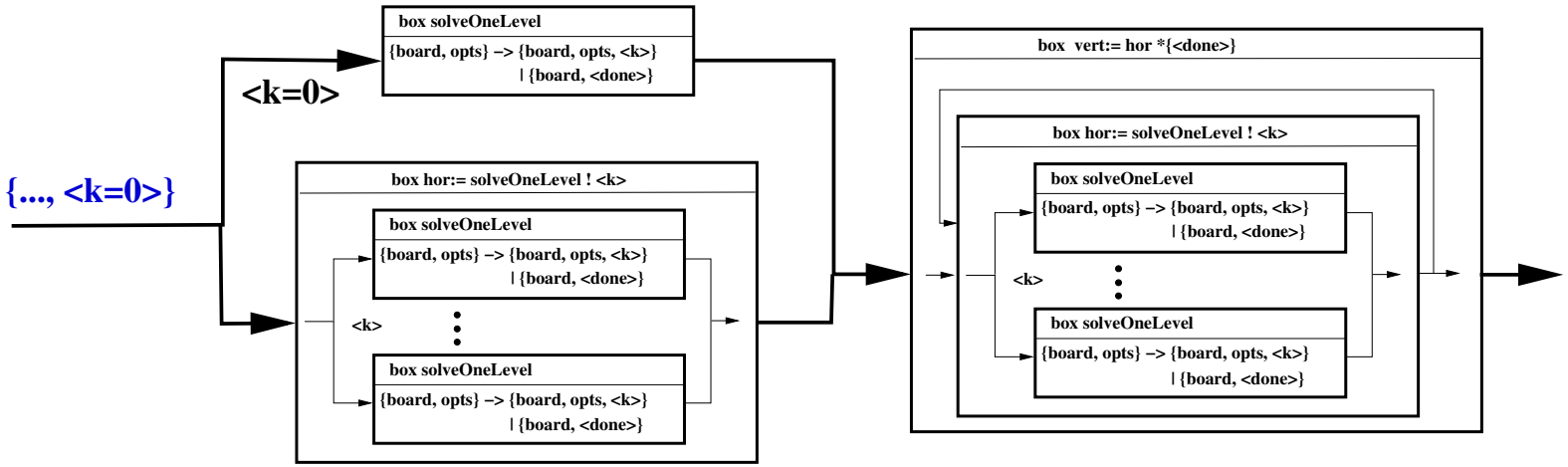

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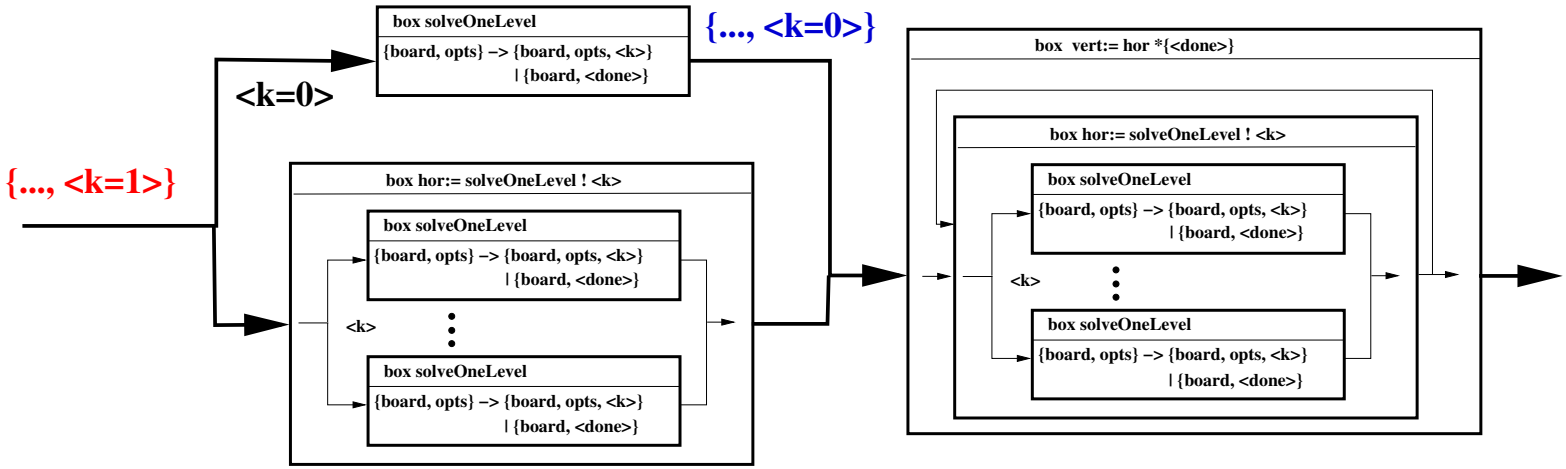

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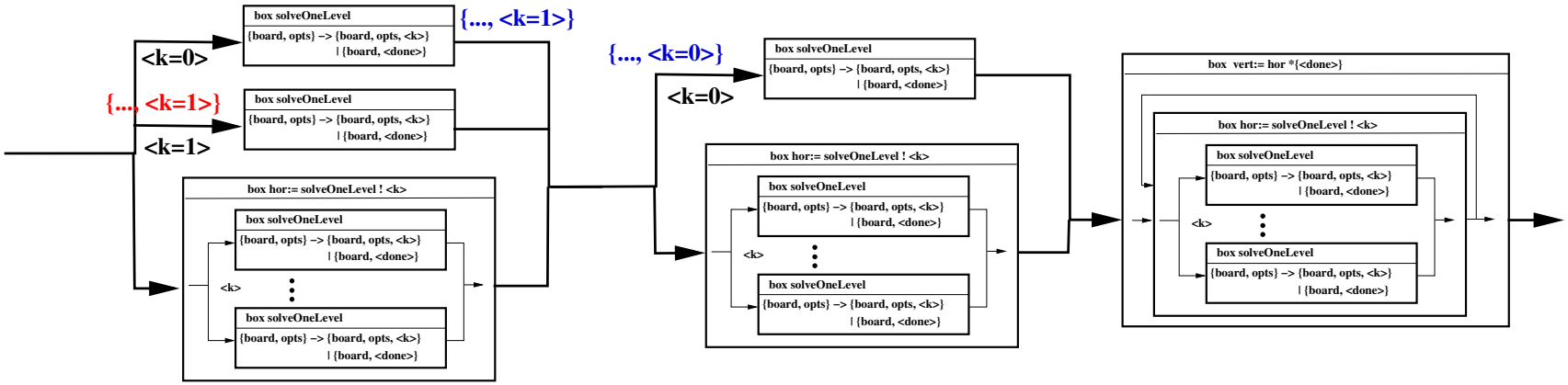

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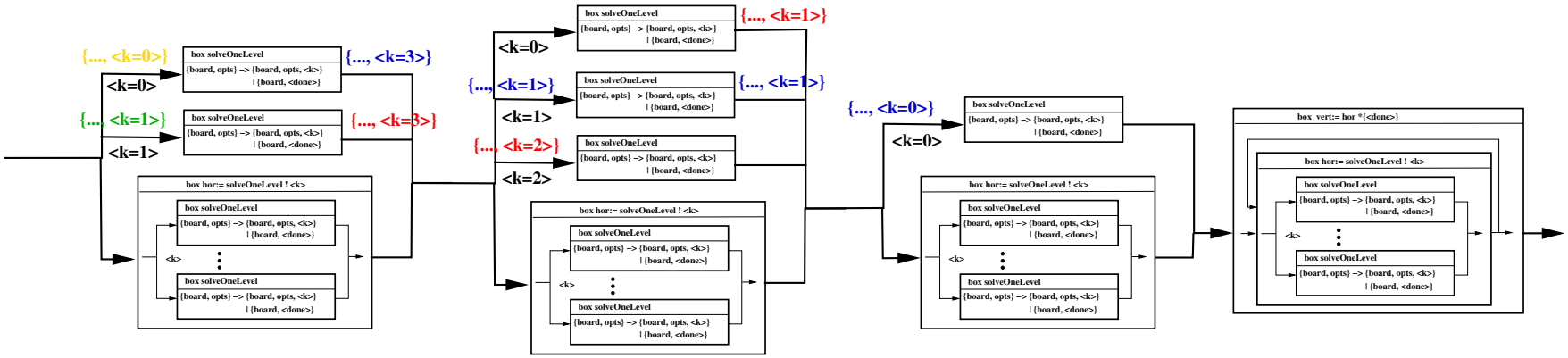

Conclusion

S-Net is

- versatile component framework
- for functional stream processing

S-Net features

- SISO as predominant construction principle
- asynchronous distributed computing
- dynamic network extension
- open box language interface
- few powerfull combinators

Current and Future Work

- prototype implementation (UH + ICL)
  - runtime system
  - compiler
- graphical tools (UH + VTT)
  - network editor
  - network simulator
- mapping to MicroThread architecture (UH + UvA)
  - hardware support for light threads
  - highly efficient synchronisation
- applications (UH + VTT + others)
  - network protocols
  - physics simulations
  - ...