Network Analysis

Monday, April 12, 2010
10:05 AM

Network analysis

- **Every solution** to Hw4 had a serious problem.
- **BPMN is not a flowcharting language.**
- Instead, it borrows its meanings from
  - Petri nets
  - π-calculus

Several impossible things before breakfast

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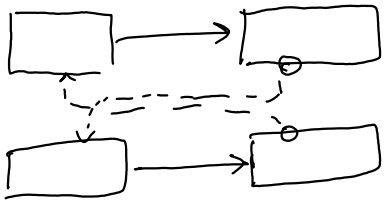
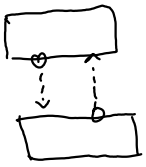
Several impossible things before breakfast

Some common BPMN weaknesses included:

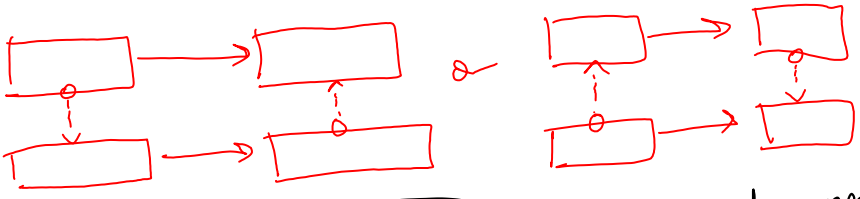


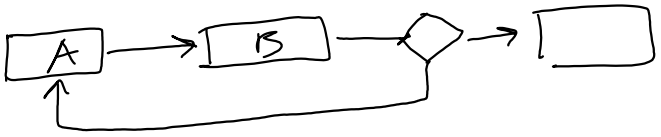
deadlock: two processes wait for each other



ambiguity: unless sequencing is explicit, it is not implied by position

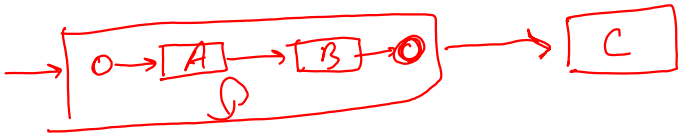
better



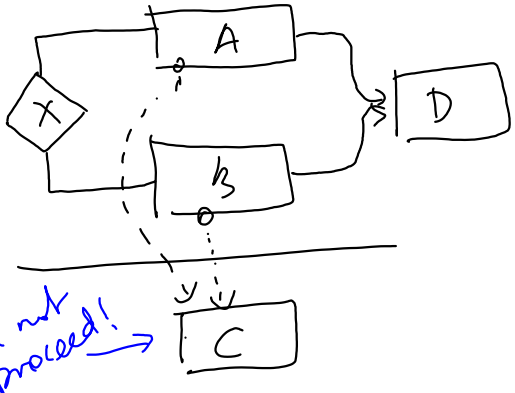


looping: not supported by BPEL.

better:



exclusive



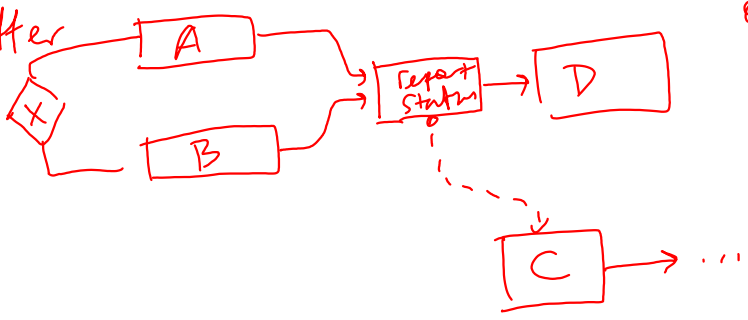
Over-constrained:

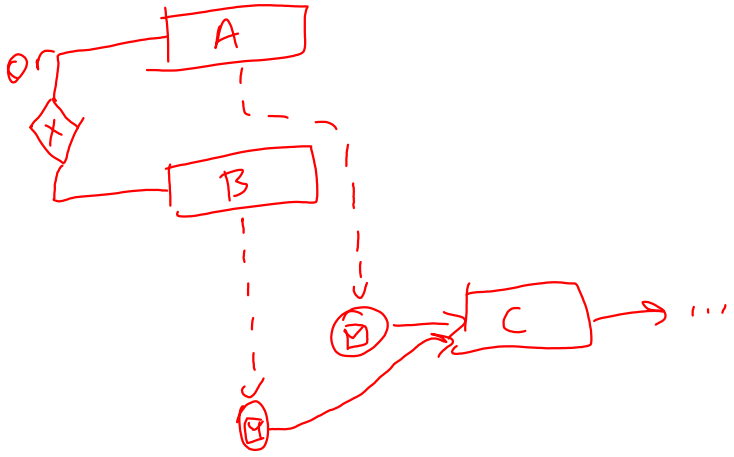
C needs messages from both A and B to proceed!

will not proceed!

Combine results, send one message

better




A
B
C
...

Petri nets

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Petri nets

- A general model of parallel computation based upon token passing.
  - Source nodes generate tokens.
  - Sink nodes eat tokens.
  - Transition nodes transform tokens in input to tokens on output.
- Computation proceeds when tokens are available.
  - Consume input tokens
  - Generate (one or more) output tokens

Petri Net Notation

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Petri Net Notation

Places: can contain state. Notated by circles.

Transitions: change state. Notated as bars.

Example:

means there is a sequence of transitions between states A, B, C

Petri sequences

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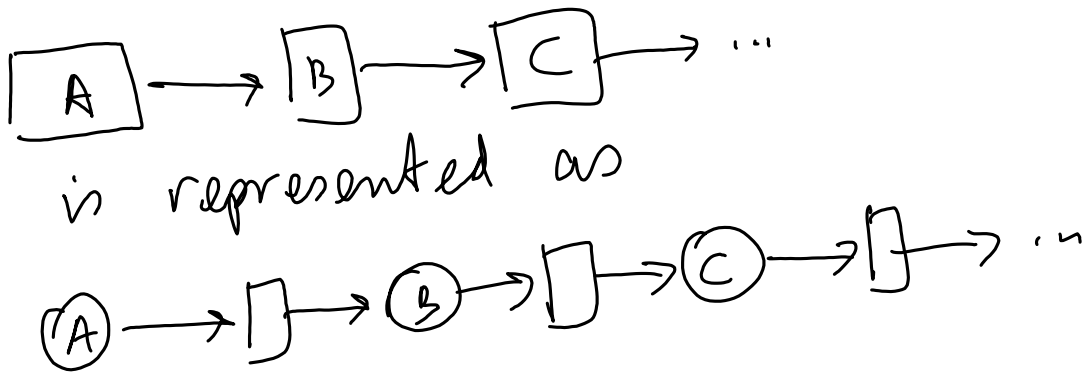
Petri sequences



Petri net tokens

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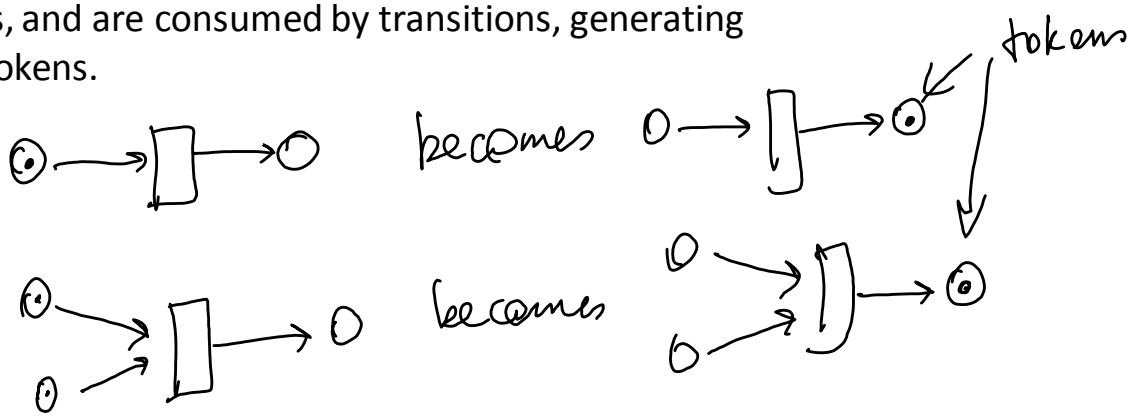
Petri net tokens

Model of execution: token passing

Tokens are generated by sources, accumulate at places, and are consumed by transitions, generating new tokens.



Petri net rules

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Petri net rules

Every place node must be connected only to transition nodes.

Every transition node must be connected only to place nodes.

Thus the Petri net is **bipartite** with two kinds of nodes.

○ = place node = state

□ = transition node

ⓐ = place node with token

Petri logic

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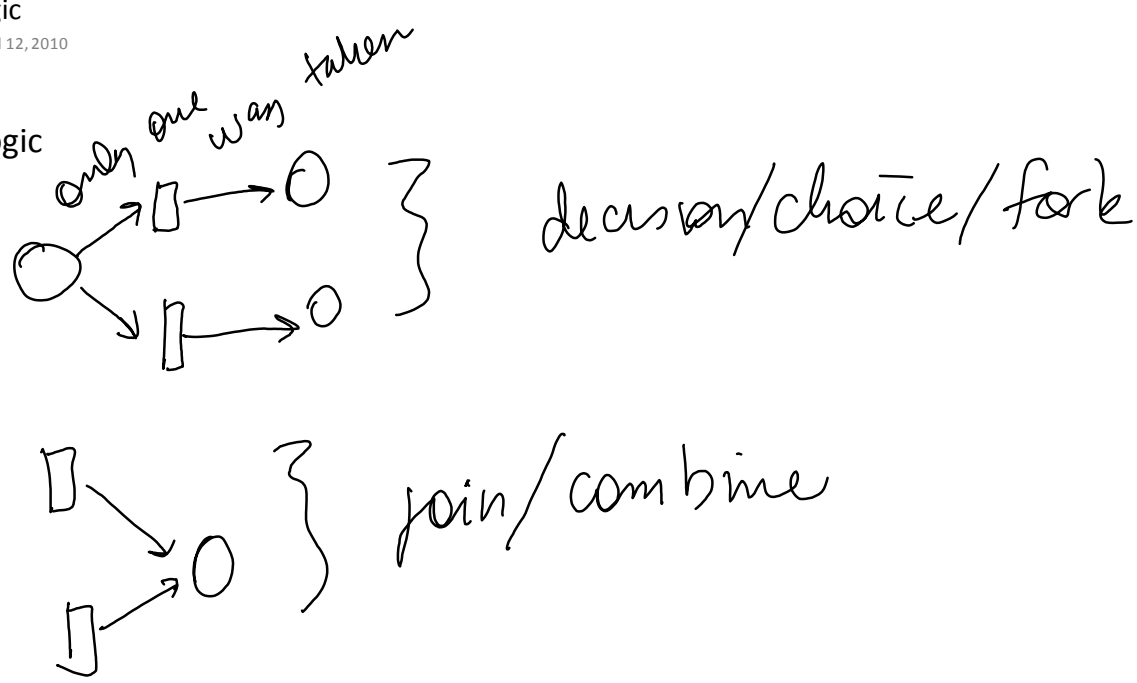
Petri logic



Petri net constructions

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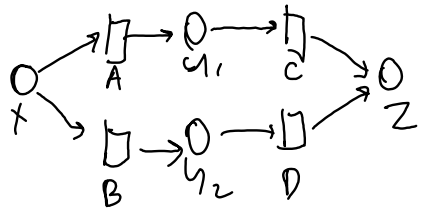
Petri net constructions



a decision: only 1 of A, B can fire at a time.
exclusive-or

a join: either C or D can make the transition to Z

A Petri model of BPMN

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A Petri model of BPMN

- Message arrows and precedence arrows become token arrows.
- Start nodes become token sources.
- End nodes become token sinks.
- Implicit transition nodes become explicit.

From BPMN to Petri net

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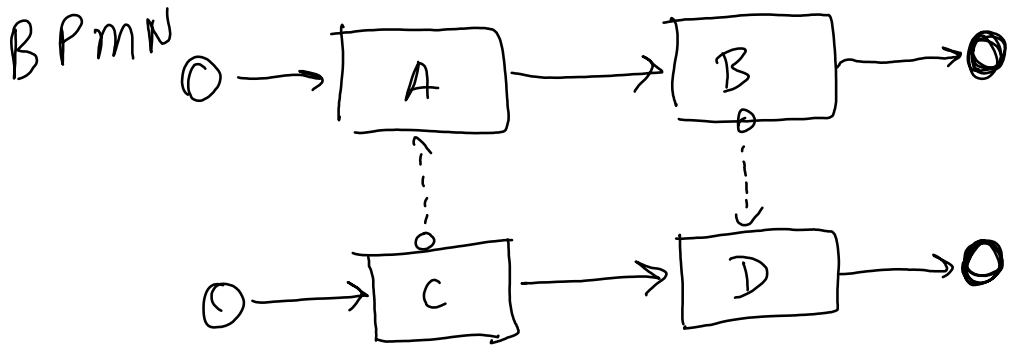
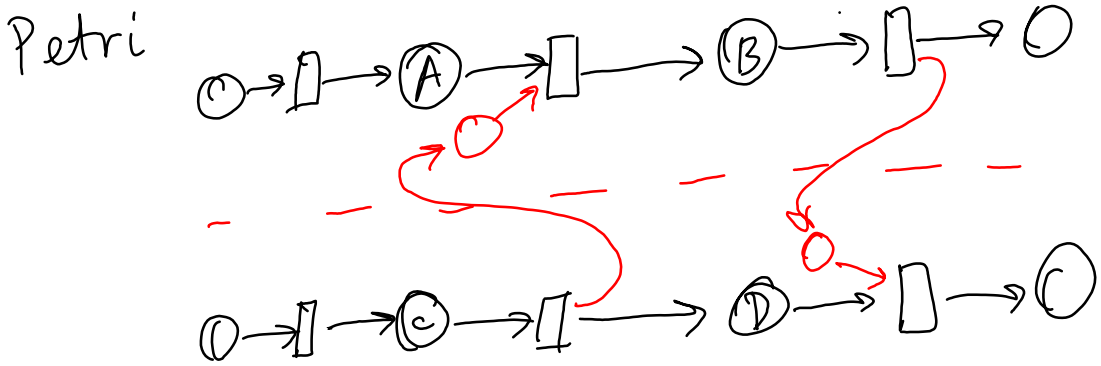
From BPMN to Petri net





Notes:

Message receipt

causes a state transition, i.e., a token in a new place.

is a prerequisite for the next step.

Or, sorting things out a bit

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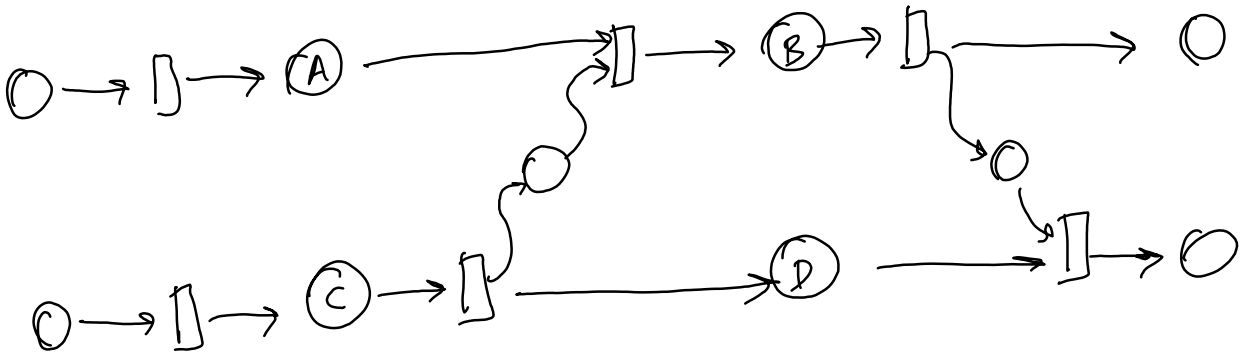

Petri Net Computation: start

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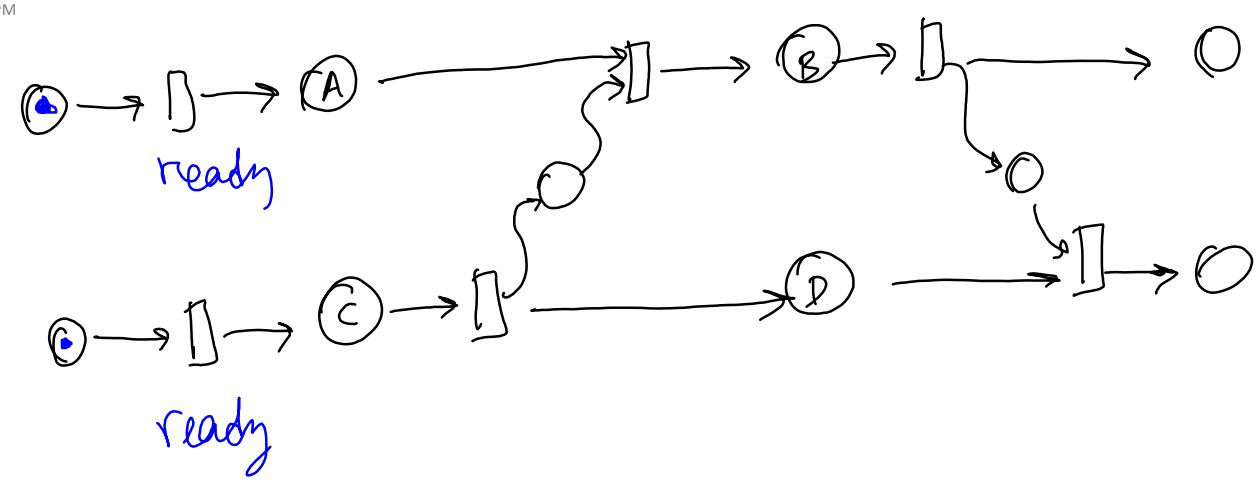

Petri Net Computation: after 1st transition

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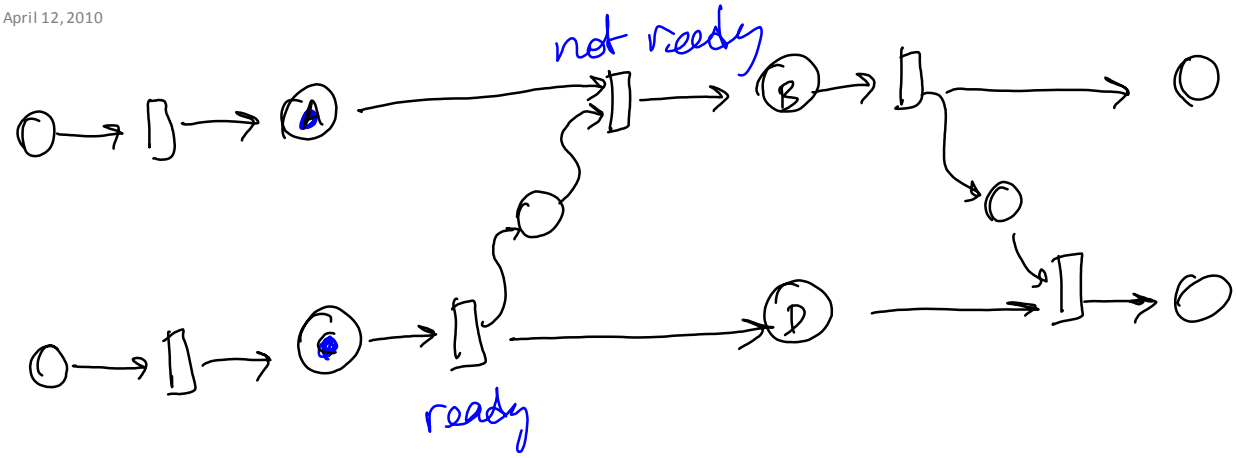

Petri Net Computation: after 2nd transition

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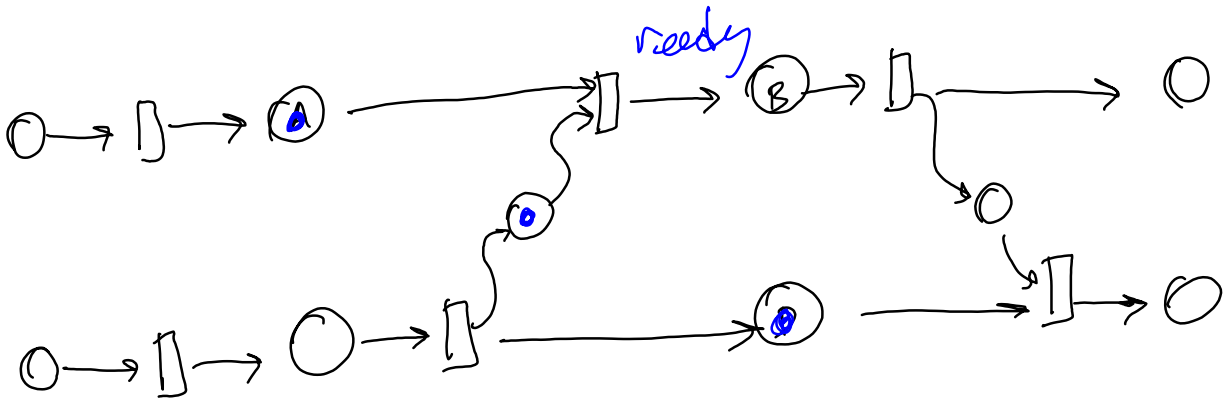

Petri Net Computation: after 3rd transition

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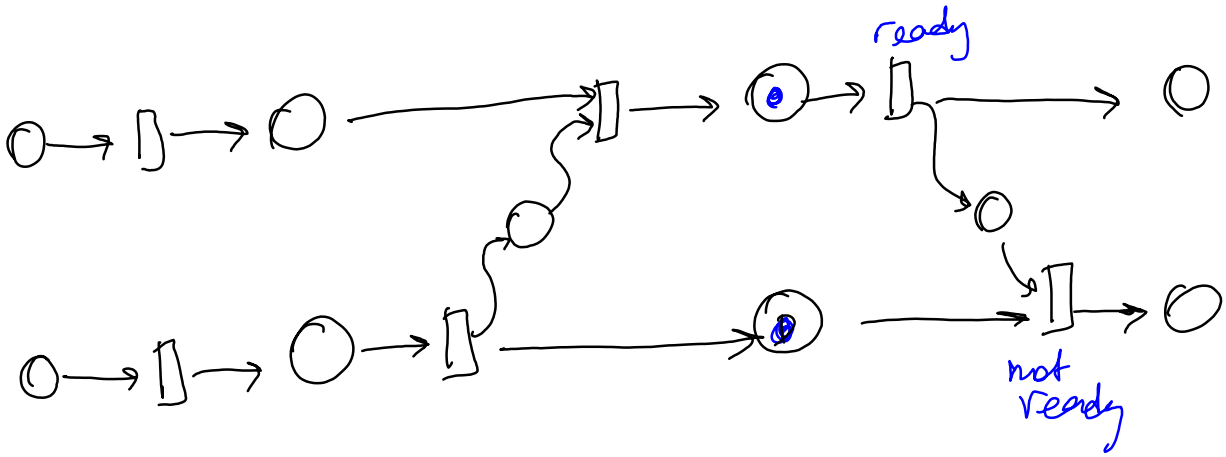

Petri Net Computation: after 4th transition

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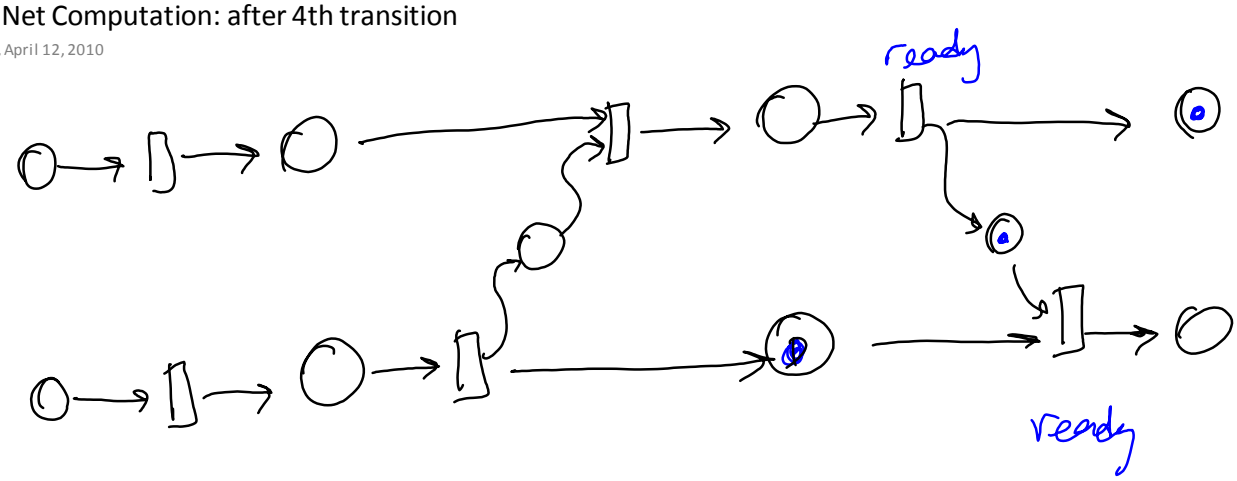

Petri Net Computation: finish

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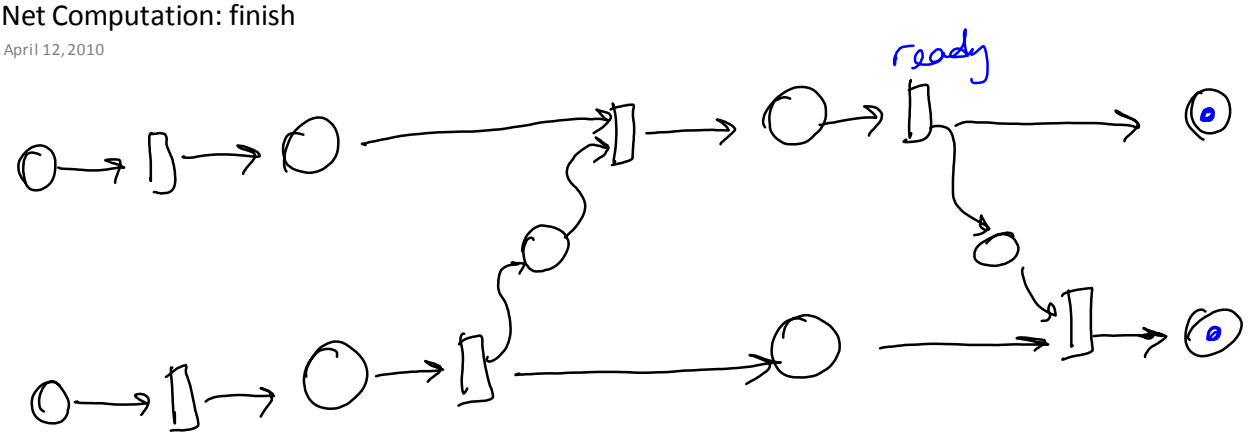

A (minor) ambiguity

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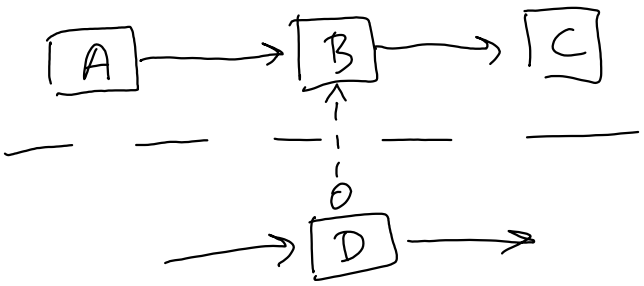
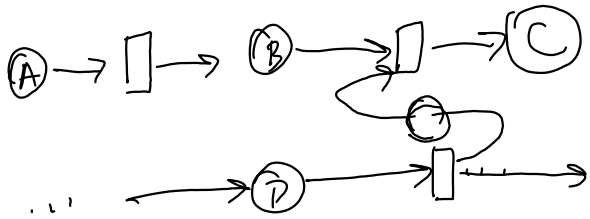
There is a minor ambiguity in translating BPMN to Petri Nets

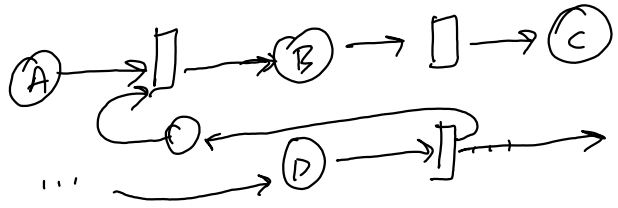


could be modeled as



need B + message before C

or



need message before B

The four constructions

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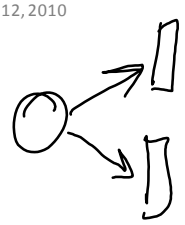
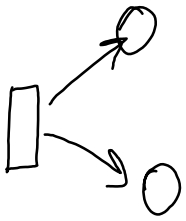
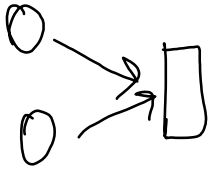


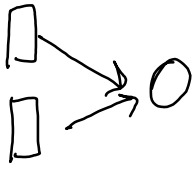
exclusive-or: decision



parallel: both at same time



and: both must have token



either/or: inclusive-or

Some easy transformations

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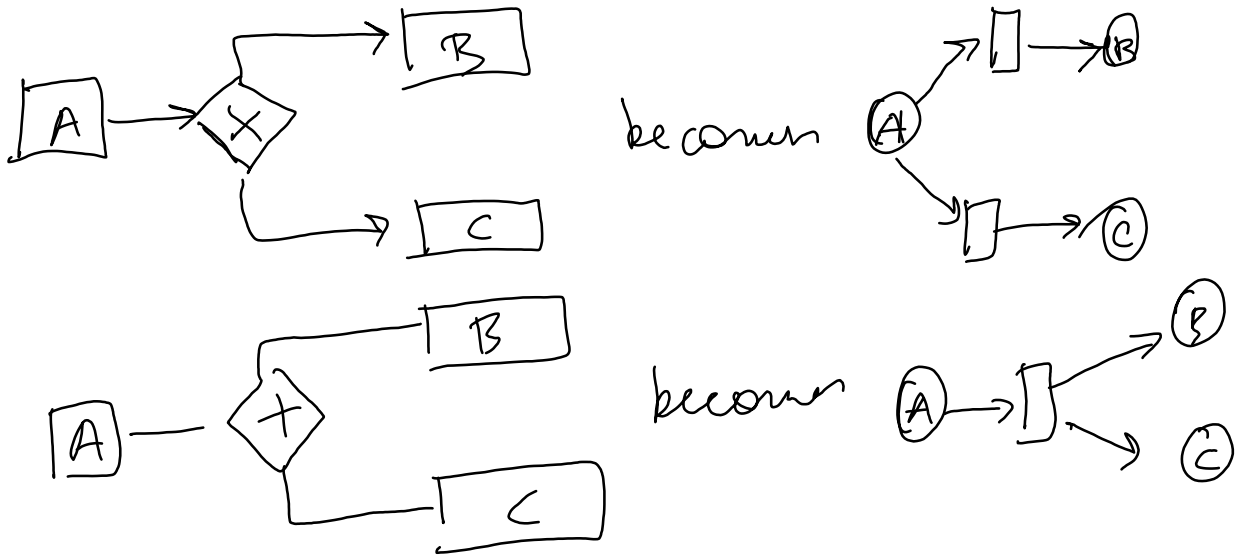

Consequences of receiving two messages

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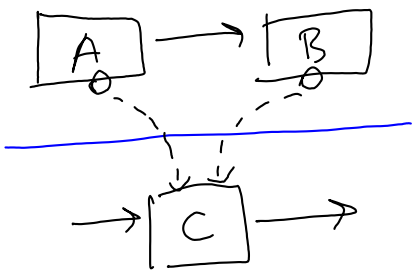
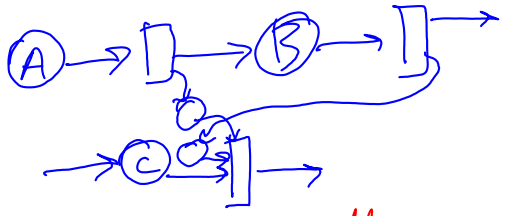


Becomes



must have <u>all</u> <u>three</u> to transition

Expressing alternative messages

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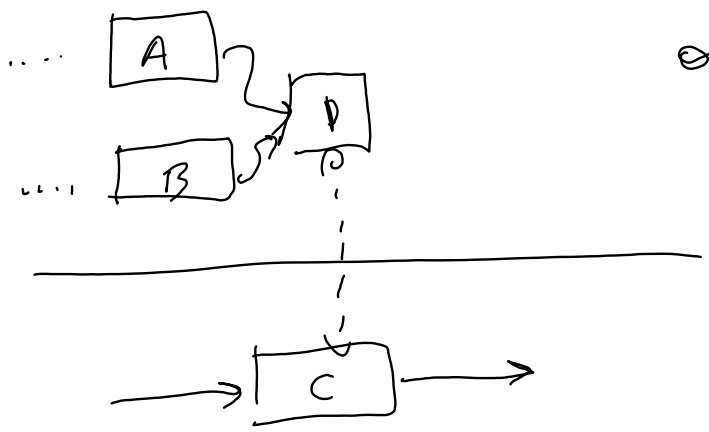
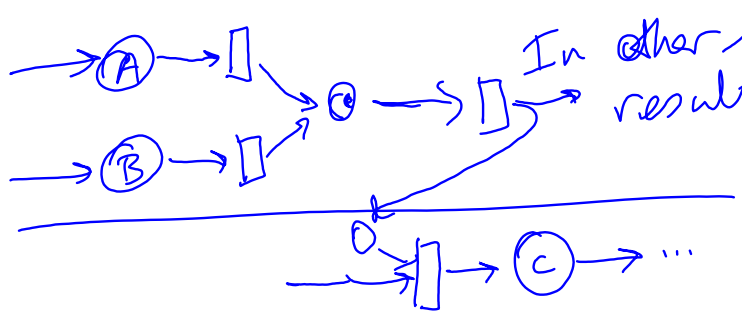


one of A or B happens,
D reports.



In other words, one state results from two things!

Why the Petri model is important

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Why the Petri model is important

- Exposes ambiguities in BPMN.
- Allows easy deadlock detection.
- Correctly models message-passing.

Poor BPMN practices reconsidered

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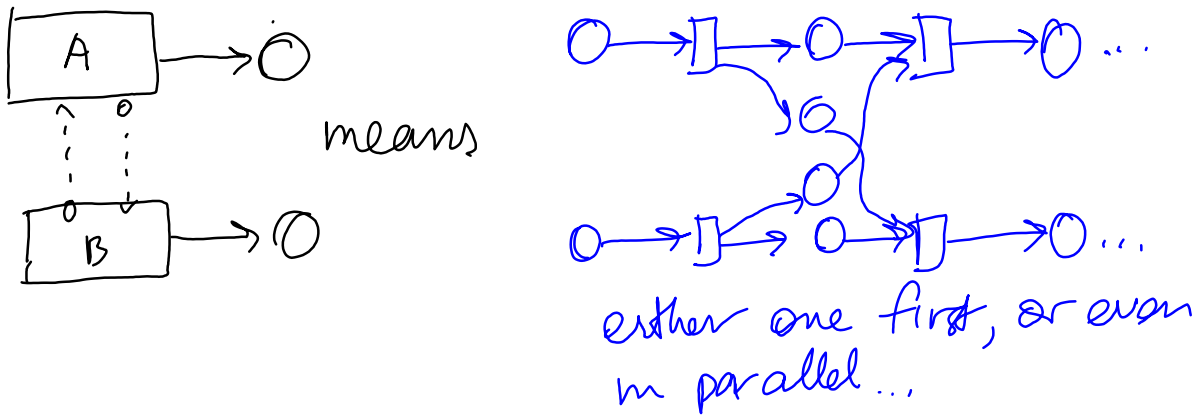
Poor BPMN practices reconsidered



Deadlock

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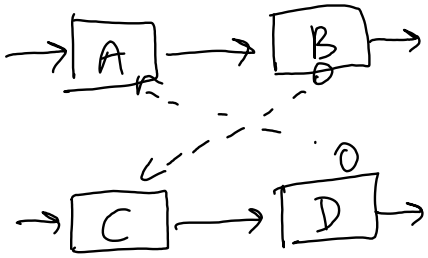
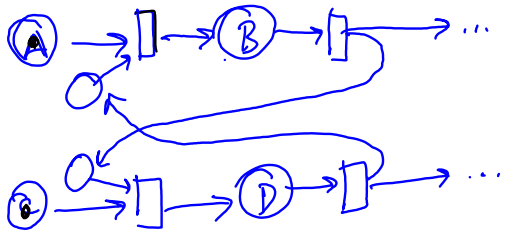
Deadlock



becomes



BPMN concepts and Petri-net extensions

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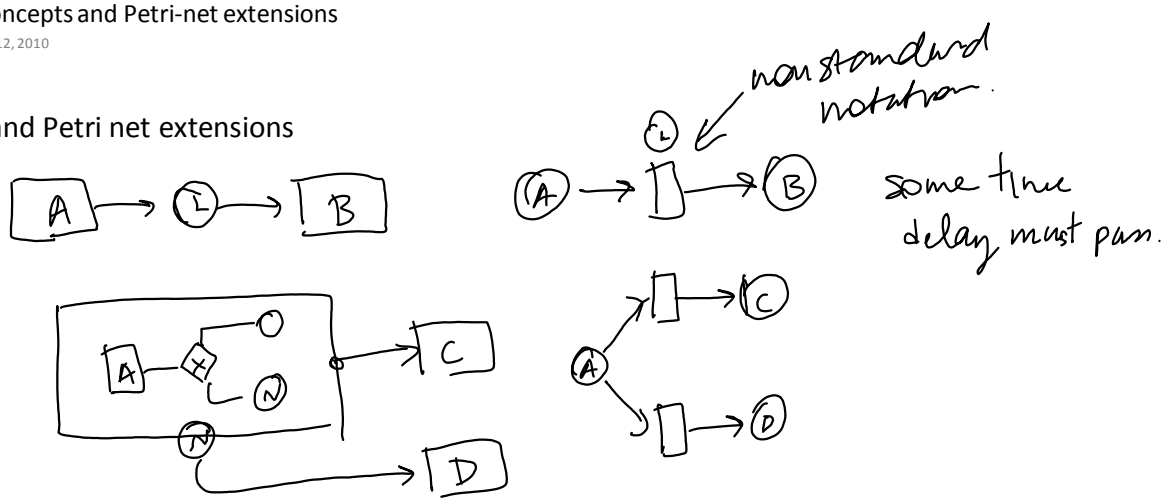
BPMN and Petri net extensions



Alas, Petri nets aren't everything

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Alas, Petri nets aren't everything

- Petri nets allow gotos.
- BPEL doesn't.
- This is a language restriction.

π-calculus

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π-calculus

- Petri nets aren't very expressive
  - No notation as to how data is used.
  - No concept of "computation".
- π-calculus: attempts to describe computation with a Petri-like model.
  - Concepts of data and binding.
  - Formal reduction as a computing model.
  - A parallel version of lambda-calculus.