IBM Research – Zurich
Process Management Technologies

The Difficulty of Replacing an Inclusive OR-Join

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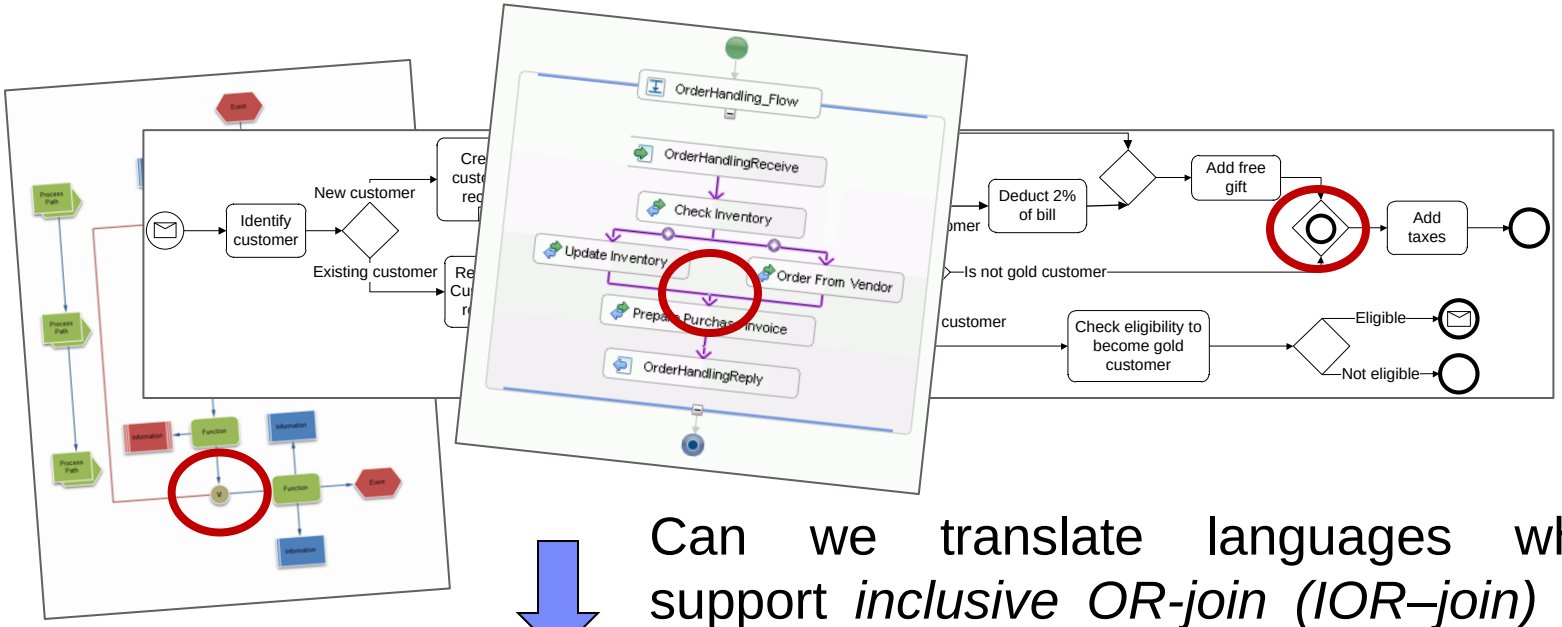
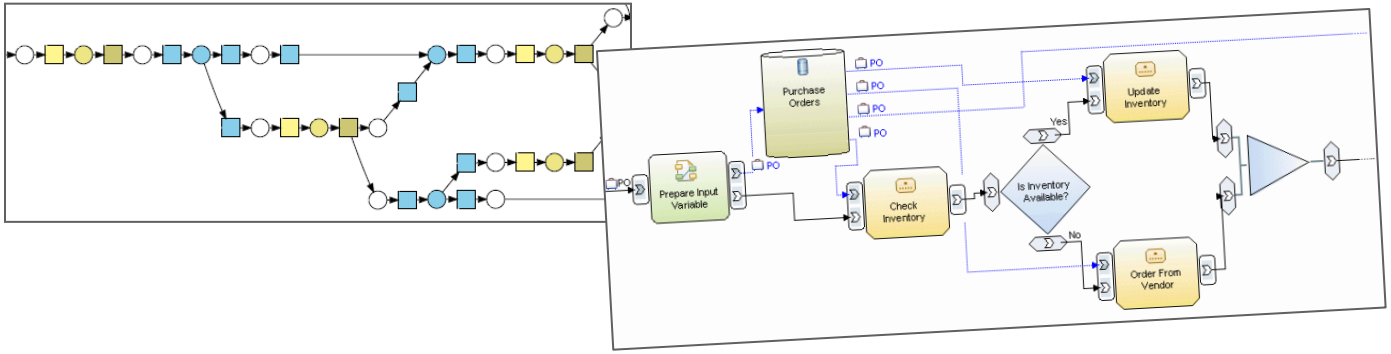
Translating an inclusive OR-join

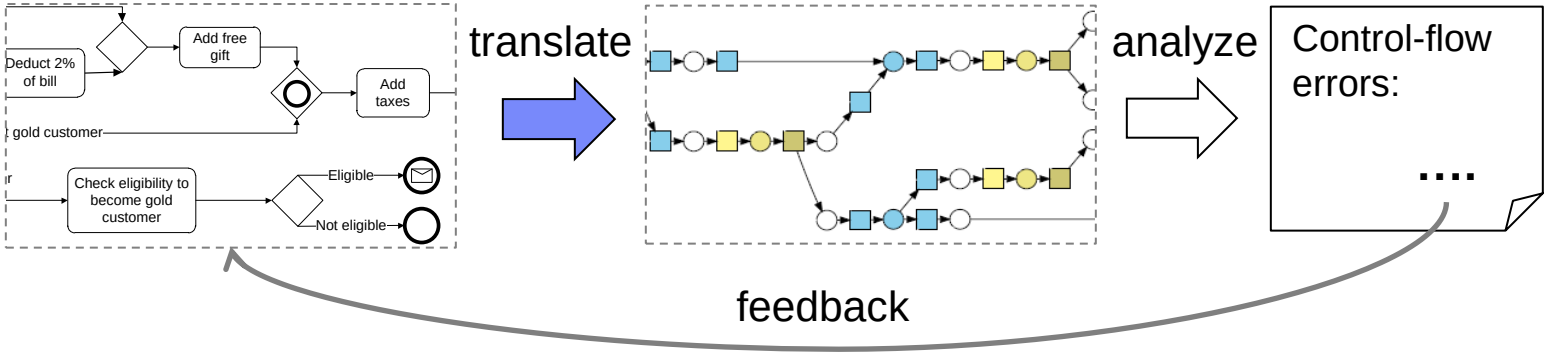


Can we translate languages which support *inclusive OR-join (IOR–join)* into languages which do not ?



Why is it relevant ?

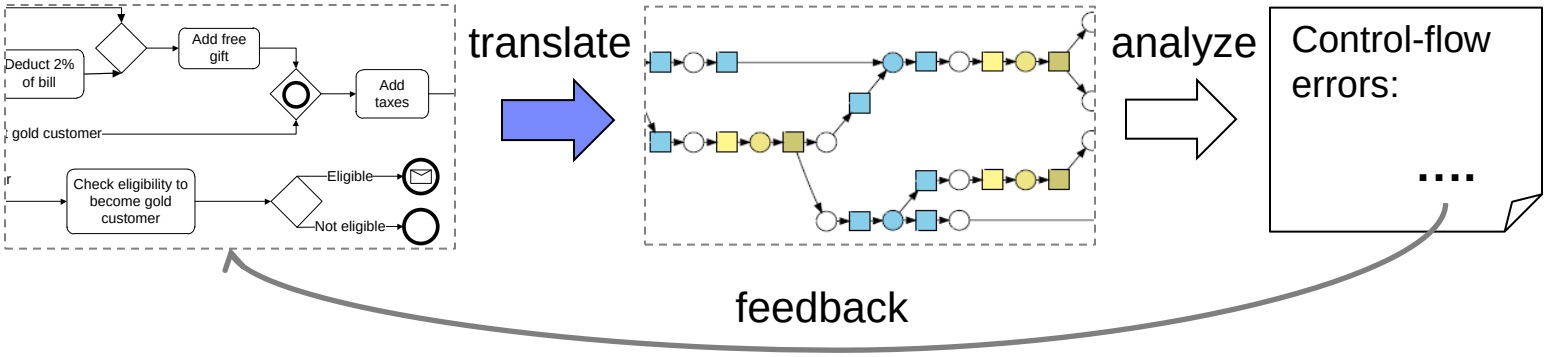
- Many analysis techniques are based on (free-choice) Petri nets: control-flow analysis, cost estimation, performance analysis, process mining …
  - Example: control-flow analysis



- Such translation is necessary to enable the use of Petri net based techniques on industrial business process models containing IOR-joins

Requirements for a translation

- Example: control-flow analysis



1. Equivalence (not difficult on its own)
   - Same “behavior” as original process
2. Size / complexity
   - An exponential blowup of the size of the model is not acceptable
3. Preservation of the original structure
   - The more structure is preserved, the easiest the analysis result can be communicated

Our work

- Restricted to acyclic processes
  - Simpler IOR-join semantics
  - Cycles can be factored out (parsing techniques)
  - IOR-joins are often used in acyclic context (e.g. BPEL)

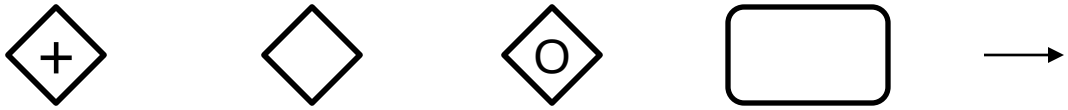
- Translating an IOR-join ?
  - Two replacement techniques and their condition of applicability
    Many occurrences of IOR-joins can be satisfactorily translated
  - An IOR-join that is difficult to translate
    No satisfactory translation for some IOR-joins occurrences

Outline

- Local replacements
- Non-local replacements
- An IOR-join that is difficult to replace

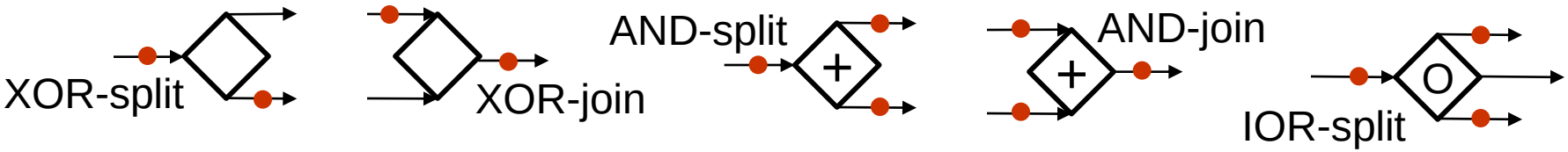
Acyclic workflow graphs

- Parallel, exclusive and inclusive gateways

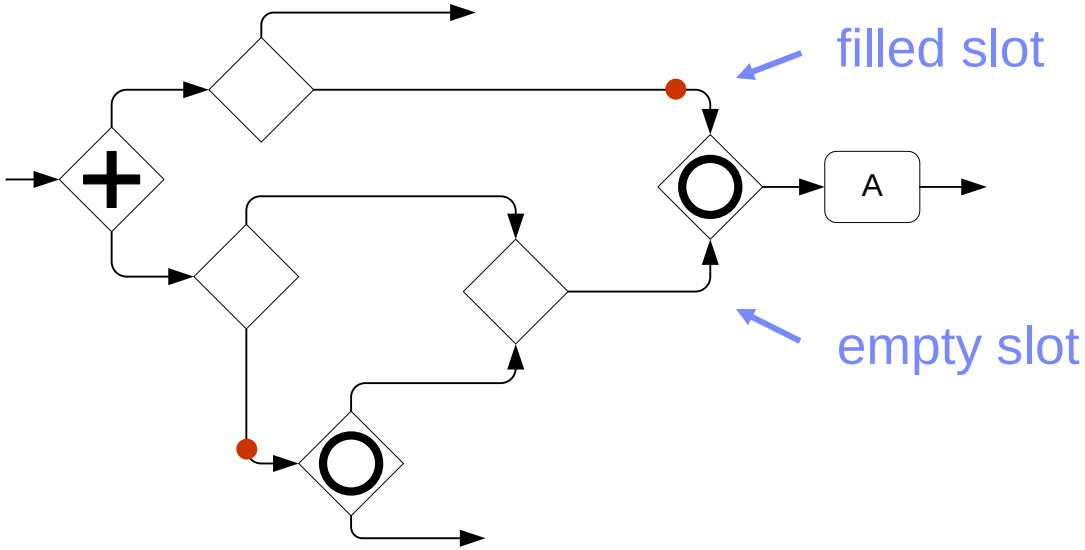


- Workflow graphs without inclusive gateways are isomorphic to free-choice Petri nets
  - **New problem**: Can an acyclic workflow graph containing an IOR-join be transformed into a workflow graph without IOR-joins?

- Semantics:

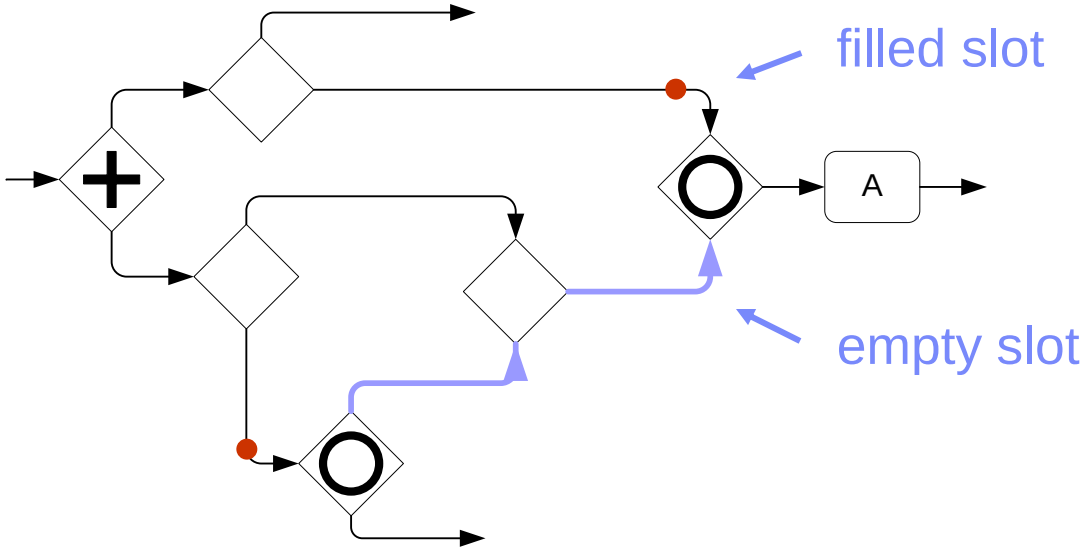


Acyclic IOR-join semantics



- IOR-join is enabled if
  - At least one slot is filled
  - It is not the case that some token "*may still arrive*" on an empty slot

Acyclic IOR-join semantics



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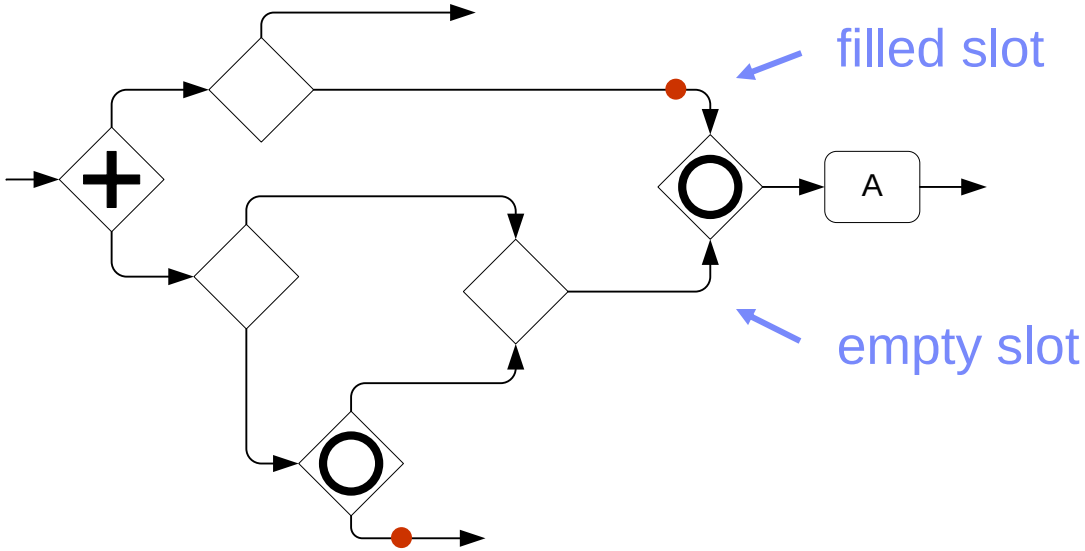

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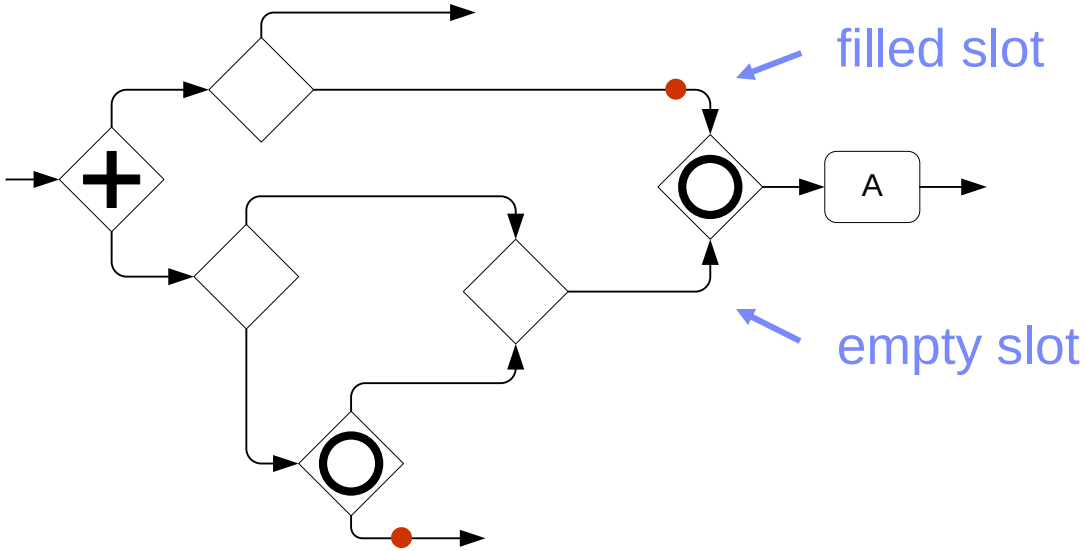

- IOR-join is enabled if
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there is a directed path from a token to an empty slot

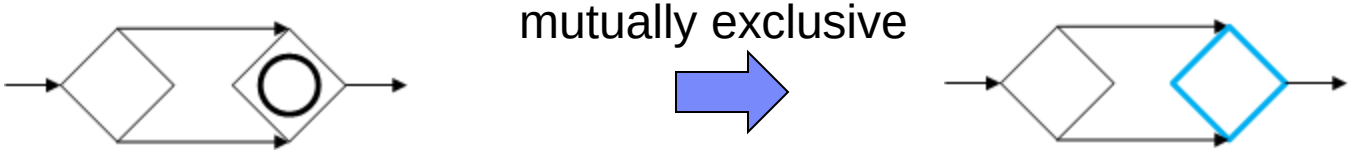
- The semantics is *non-local*
  - Enabling depends on tokens that are not at the join

Outline

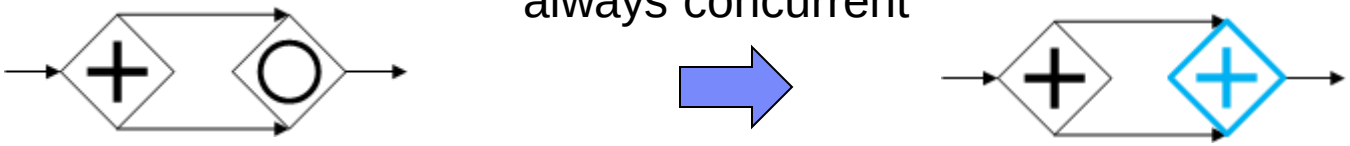
- Local replacements
- Non-local replacements
- An IOR-join that is difficult to replace

A few intuitive replacements

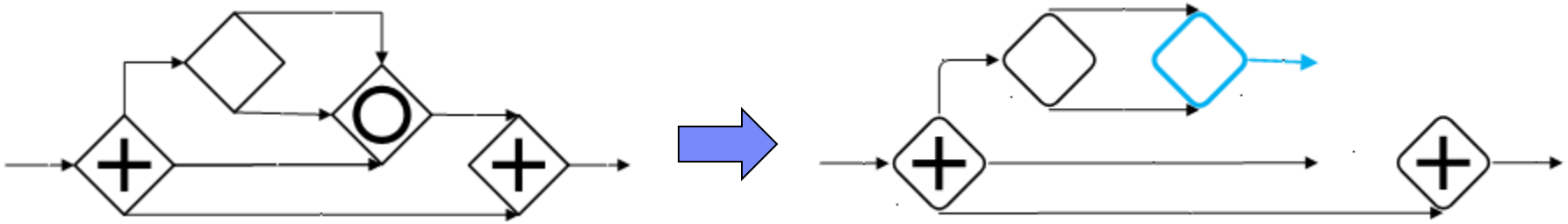
Both edges are mutually exclusive



Both edges are always concurrent



The first two edges are mutually exclusive



A few intuitive replacements

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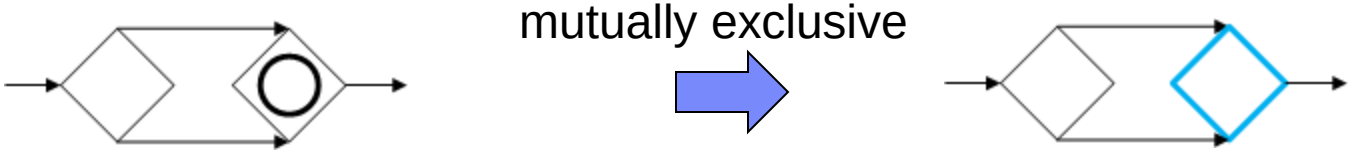

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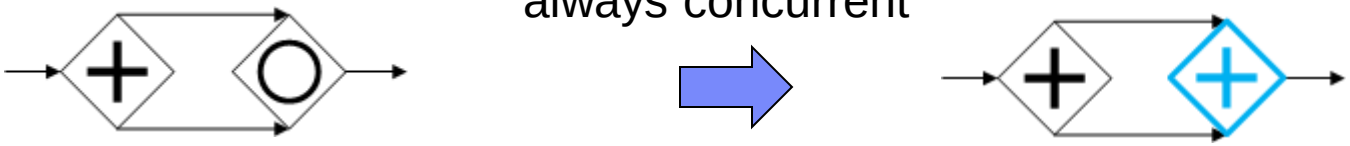
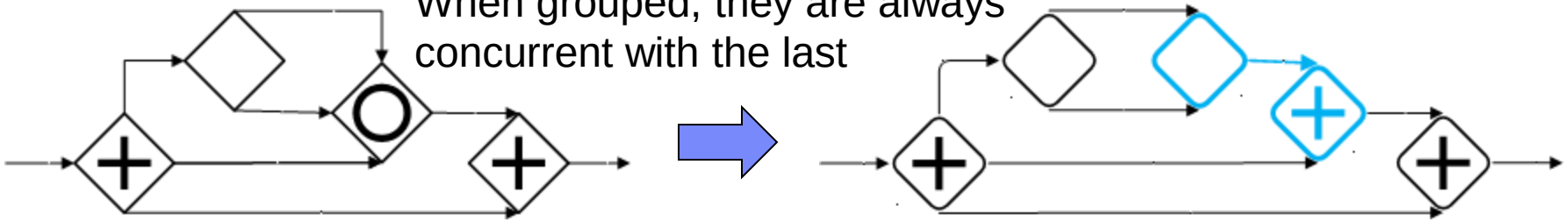
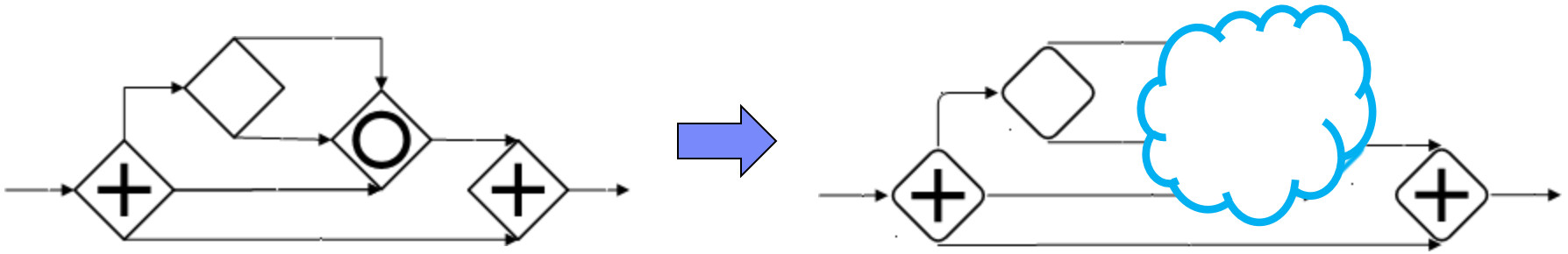


The first two edges are mutually exclusive

When grouped, they are always concurrent with the last



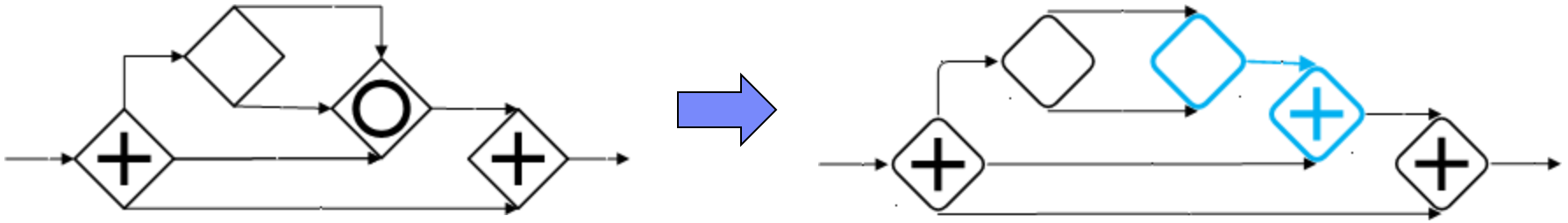
Local replacement



- Replacing IOR-join by a sub-graph (only XOR and AND)
  - Keeping the same set of I/O edges

- Advantages:
  - Intuitive notion of equivalence: “replacement must mimic IOR-join”
  - Structure preserved: rest of the workflow graph unchanged

Local replacement



- Replacing IOR-join by a sub-graph (only XOR and AND)
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- Advantages:
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Contributions

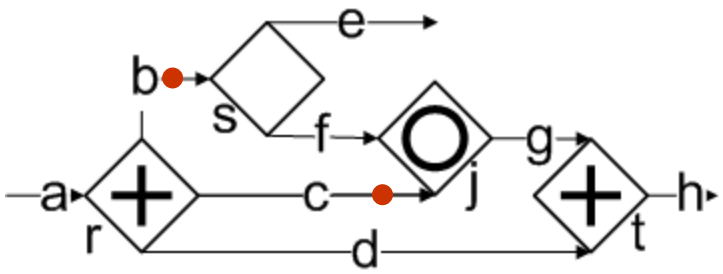
- In the paper
  - Characterization of the IOR-joins that can be replaced locally
  - Replacement technique for all locally replaceable IOR-joins

- Locally replaceable IOR-joins can be identified and replaced

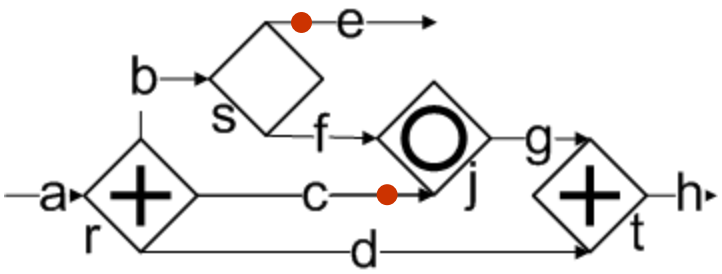
Local replacement – the limit

- The local replacement is using gateways with local semantics and only using local information

- The local information is not enough to differentiate:



Not enabled



Enabled

Outline

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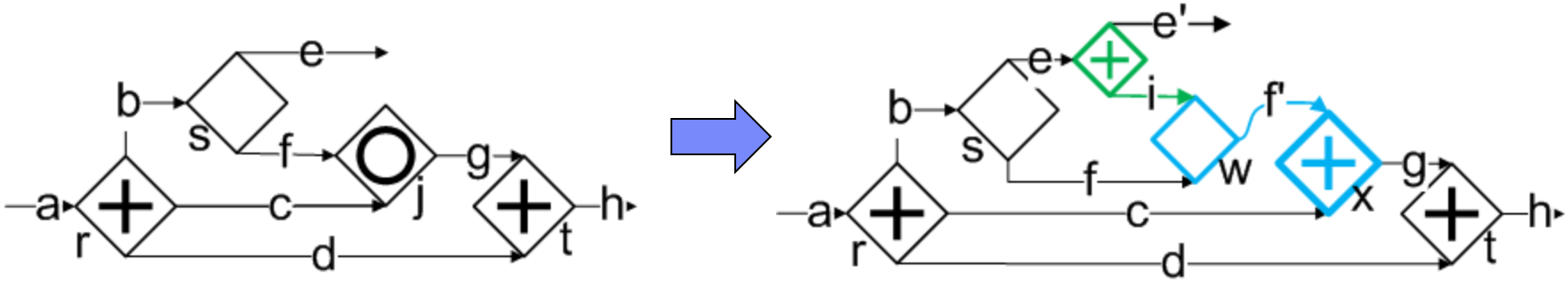
- An IOR-join that is difficult to replace

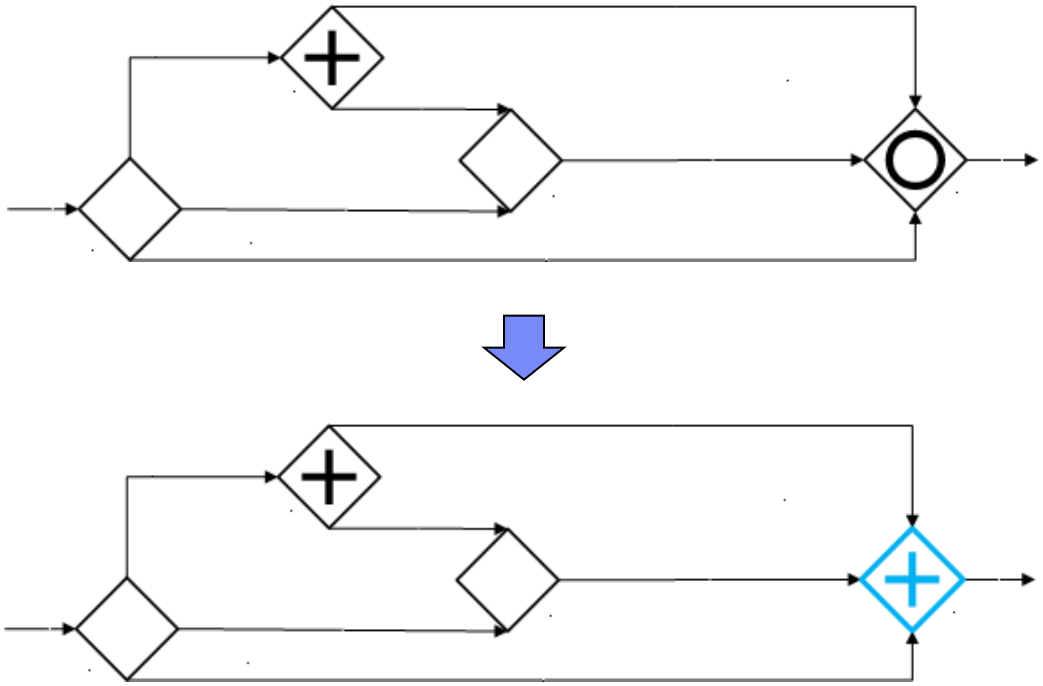
Non-local replacements



- Idea
  - Transmit the missing information using bridges
- Non-local replacement = local replacement + bridges

Simple K-replacement

- Idea [Kiepuszewski et al., completion of processes]
  - Replace IOR-join by an AND-join
  - For each incoming edge, “bridge” all the tokens that are “lost”



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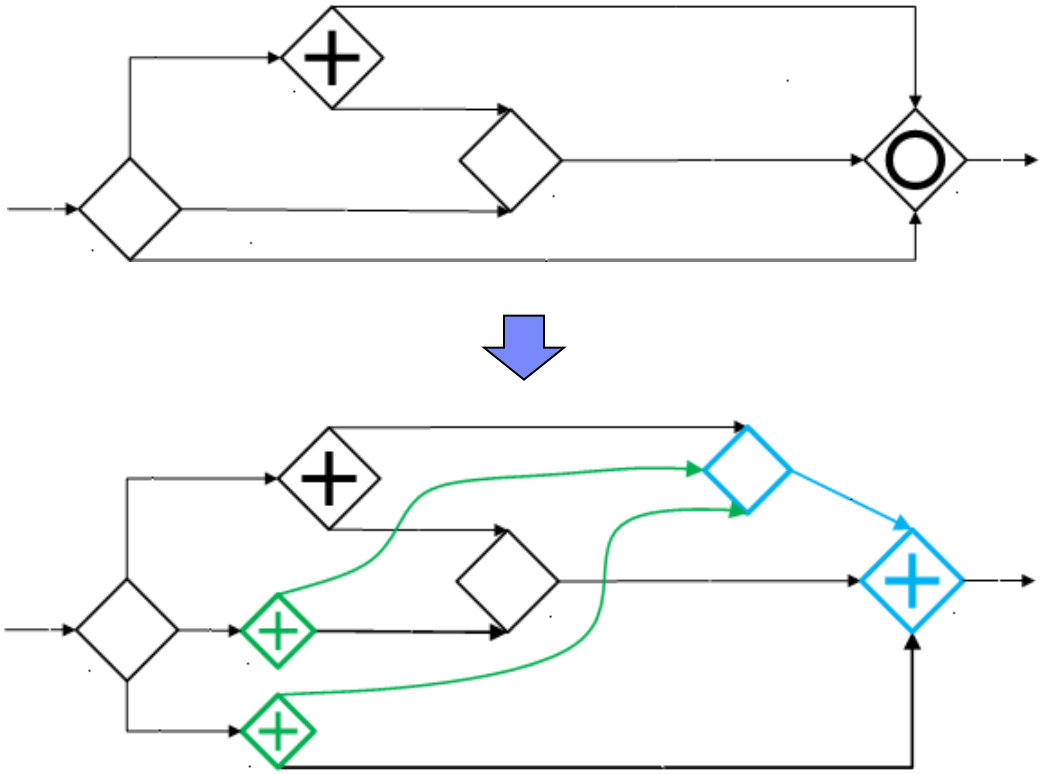

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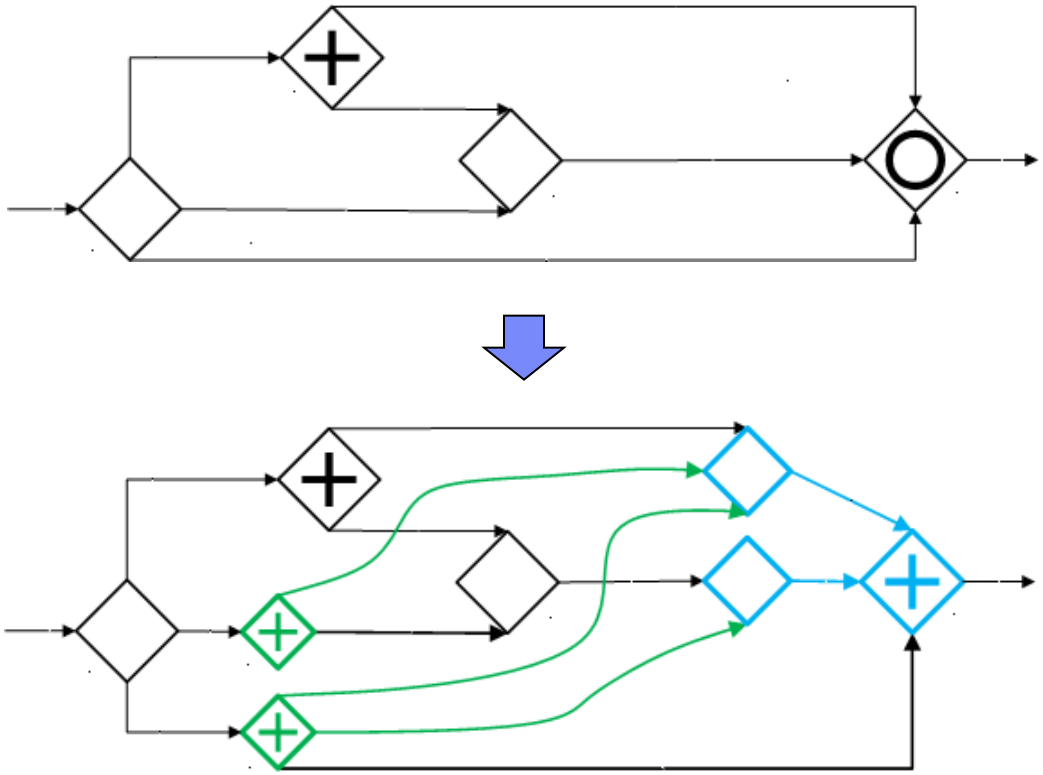

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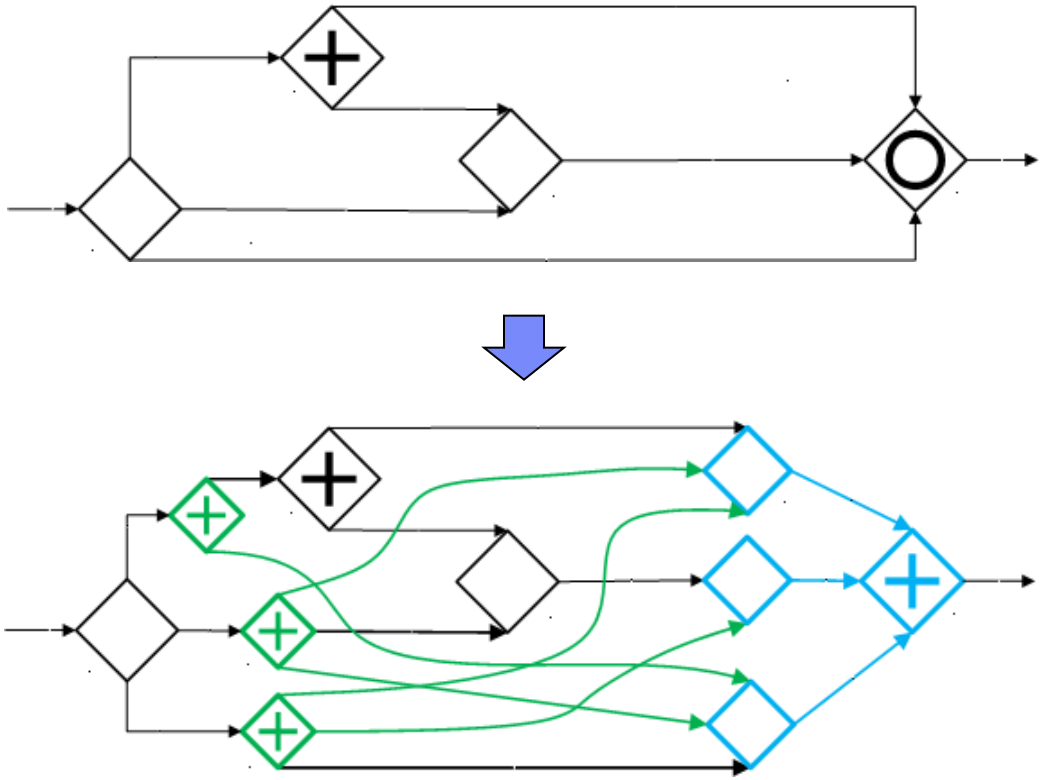
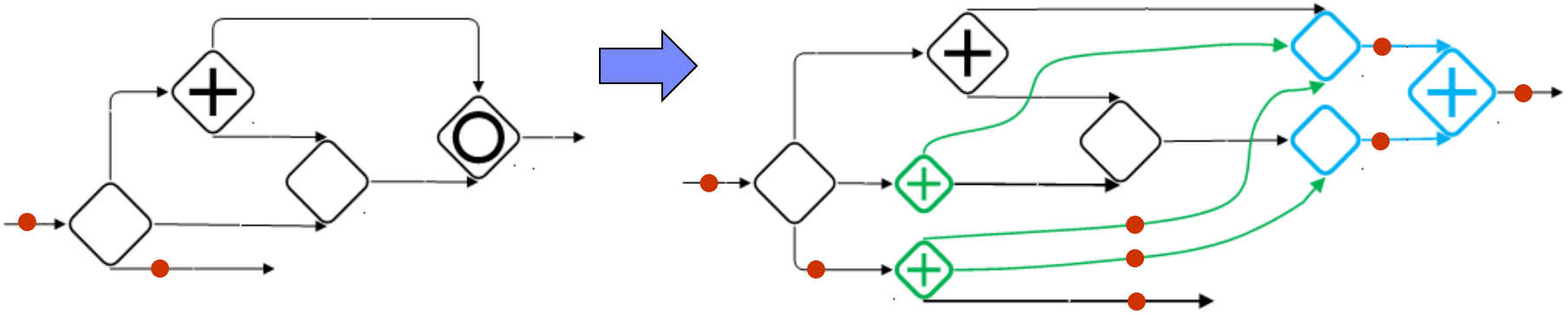


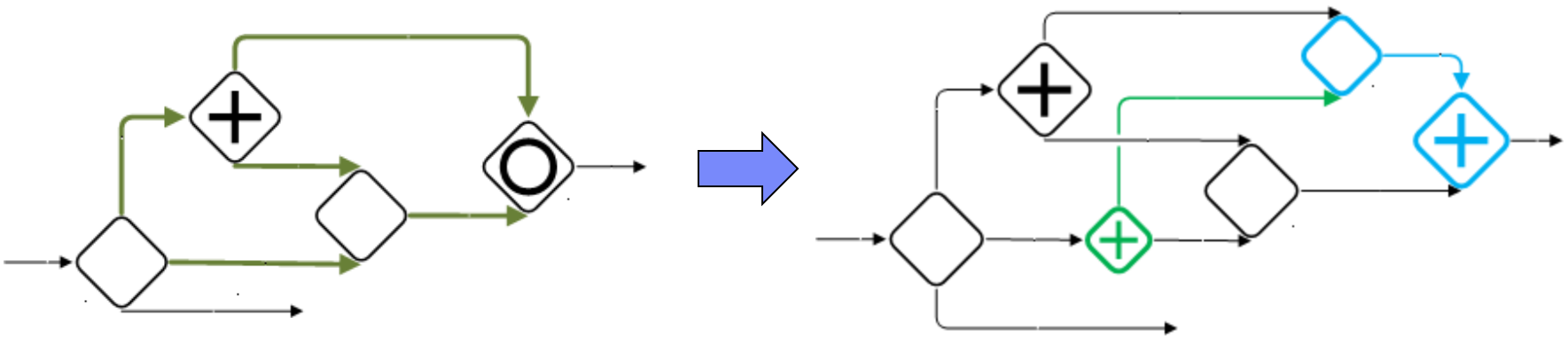
Simple K-replacement problem

- The replacement is executed during every execution, but some IOR-joins do not



- Idea
  - Reduce the area of application

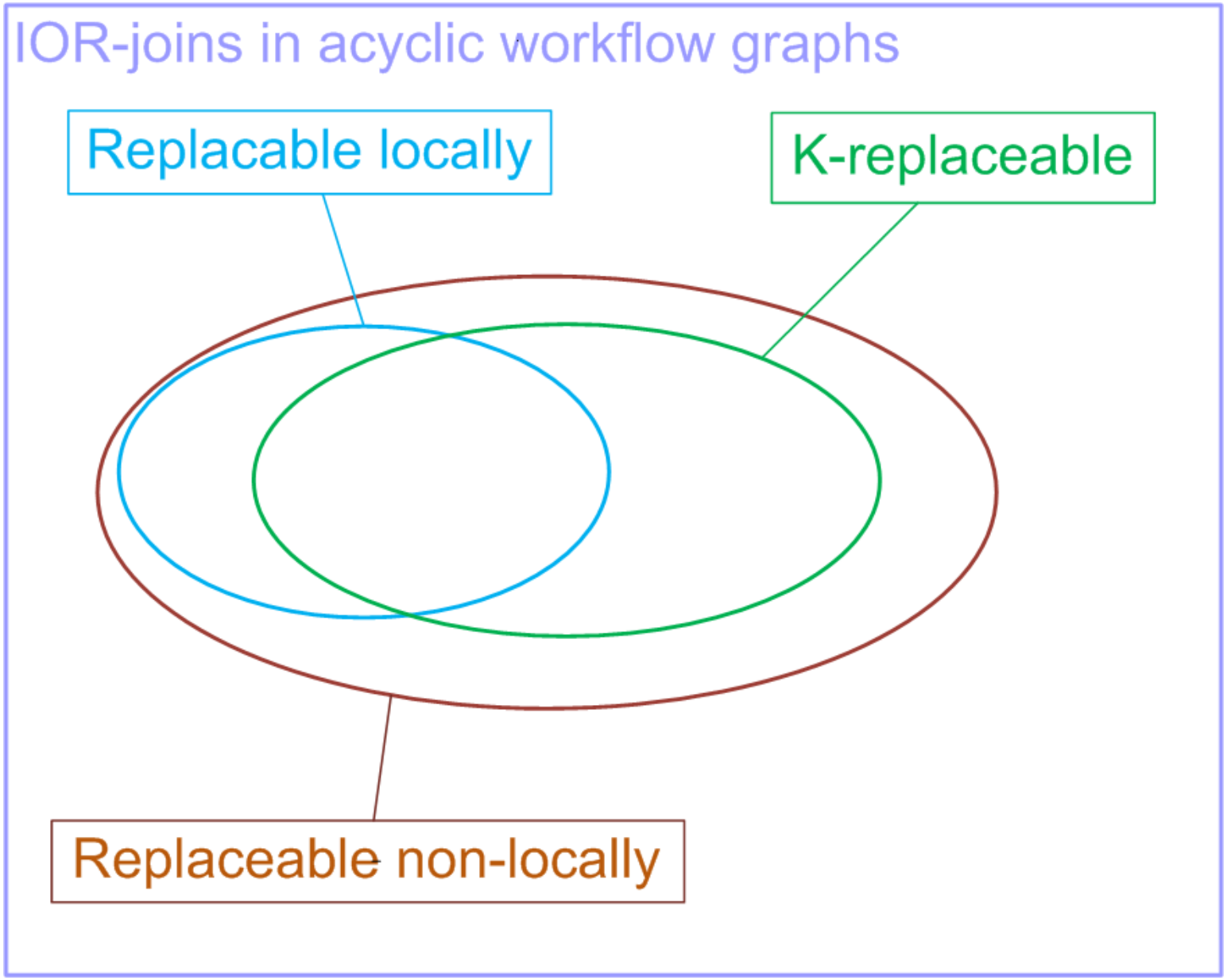
K-replacement - reduced area of application



- In the paper
  - ***K-replacement*** (reduced area of application)
  - A condition of applicability which can be checked in polynomial time

- We can identify K-replaceable IOR-joins and replace them in polynomial time

IOR-joins in acyclic workflow graphs



Outline

- Local replacements
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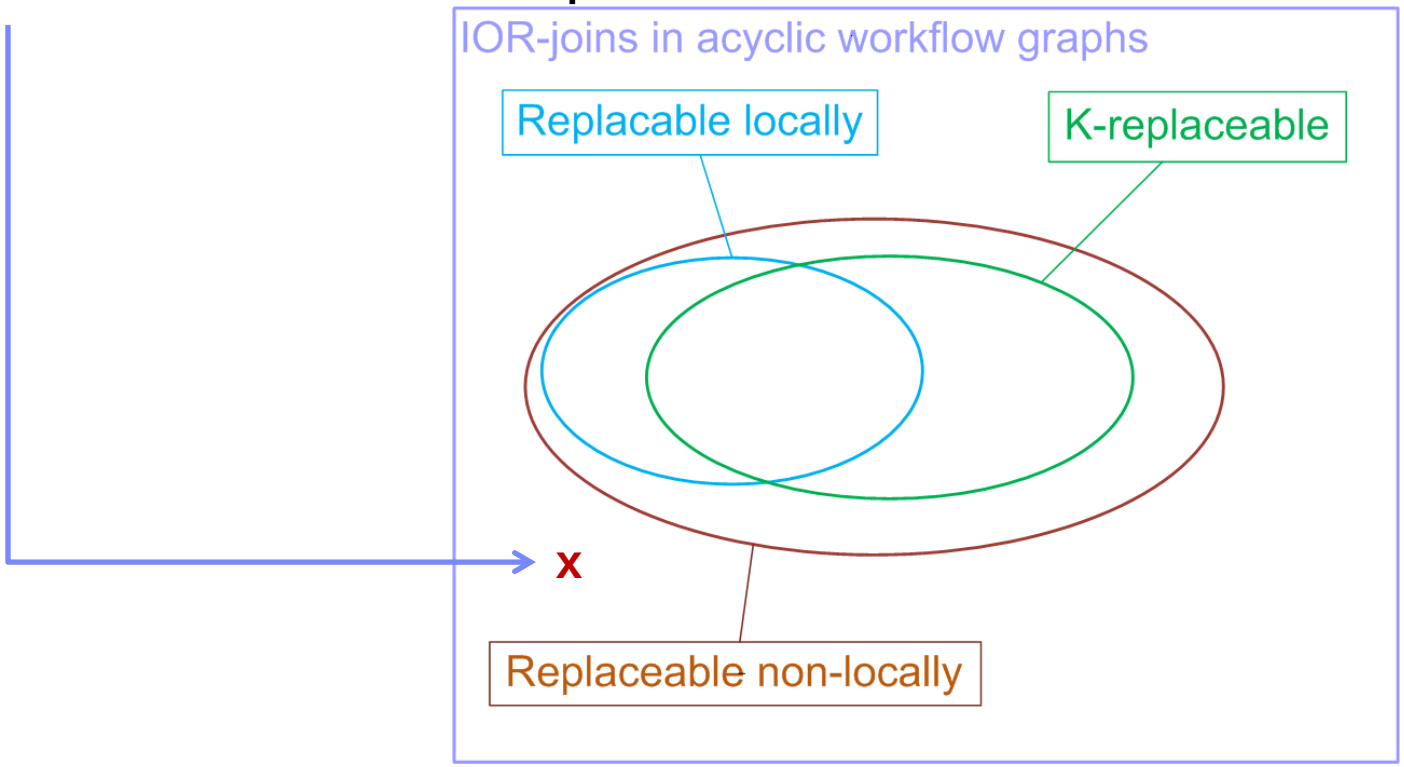
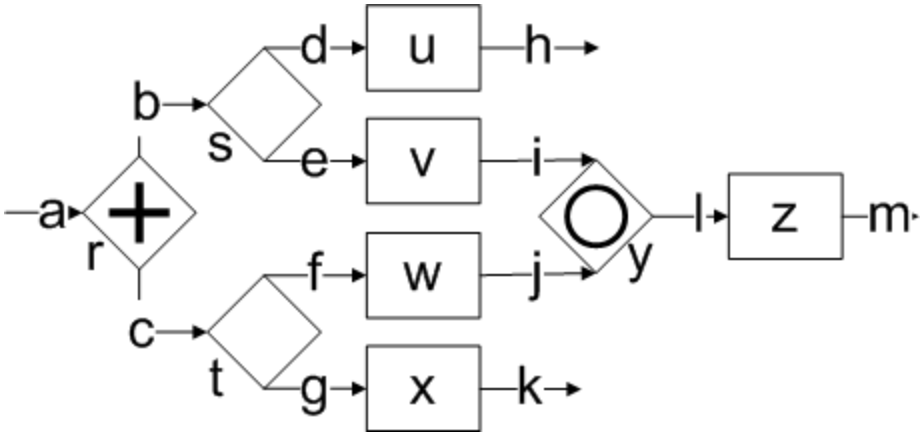
- An IOR-join that is difficult to replace

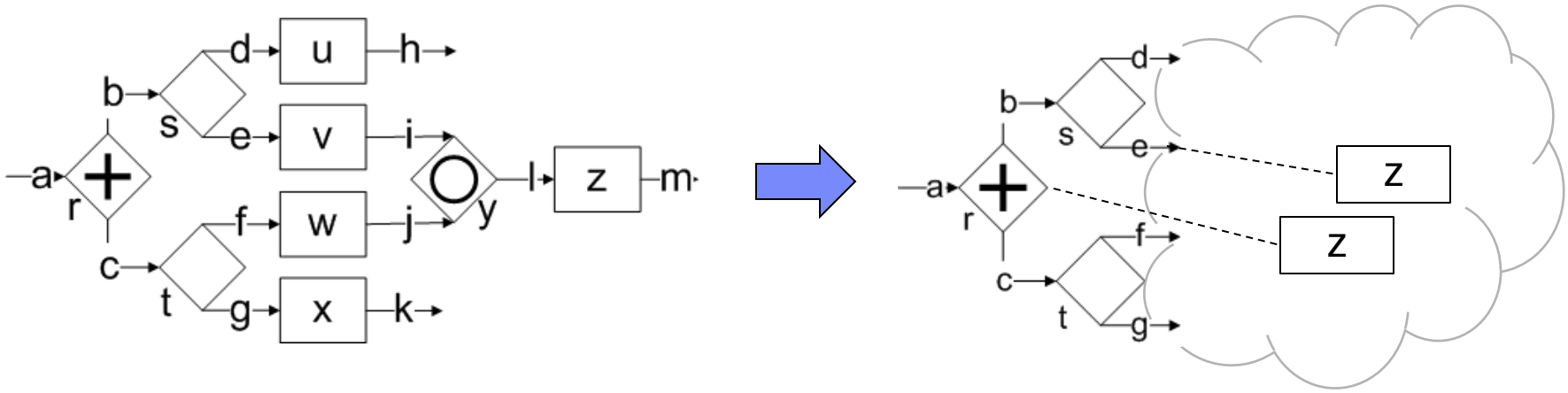


An IOR-join which is difficult to replace



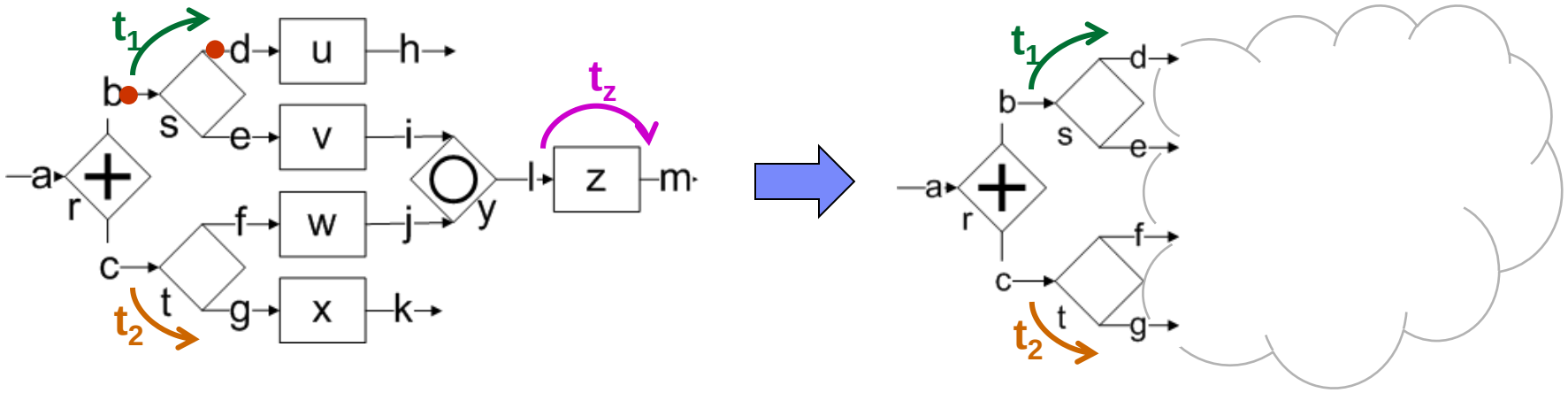
- Cannot be:
  - locally replaced,
  - K-replaced
- We will show that the synchronization role played by *y* cannot be obtained using AND and XOR logic

The synchronization role of y cannot be replaced



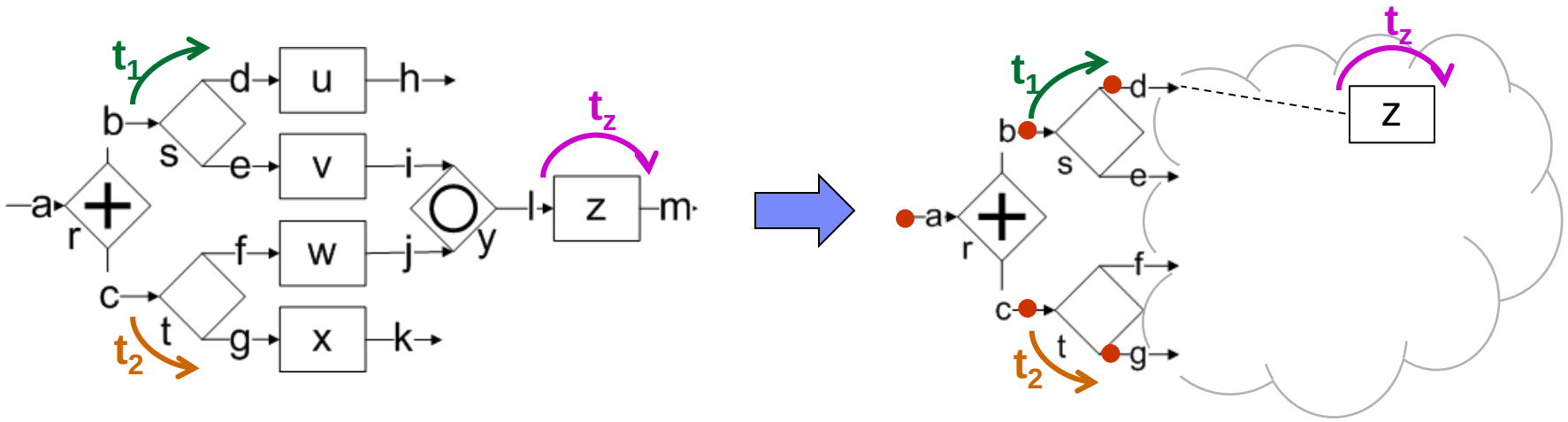
- Question: can we complete the prefix to obtain same behavior
  - Tasks can be copied, edges of the prefix can be bridged
- In the paper, we show that the prefix cannot be completed using AND and XOR logic

The prefix cannot be completed



- Execution properties
  - There exist executions where t_1 and t_z execute and, in executions where t_1 and t_z are executed, t_1 always executes before t_z
  - There is no execution executing t_1, t_2, and t_z

The prefix cannot be completed



- Execution properties
  - There exist executions where t_1 and t_z execute and, in executions where t_1 and t_z are executed, t_1 always executes before t_z
    → **there is a path from t_1 to t_z in the completion**
  - There is no execution executing t_1, t_2, and t_z

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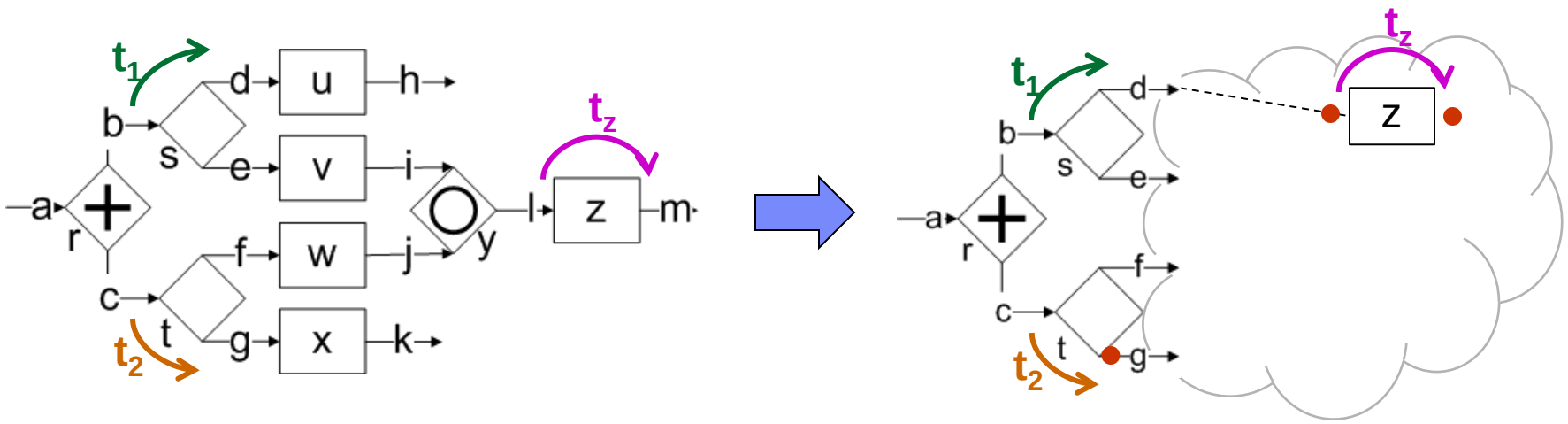

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    → **this path can be executed**
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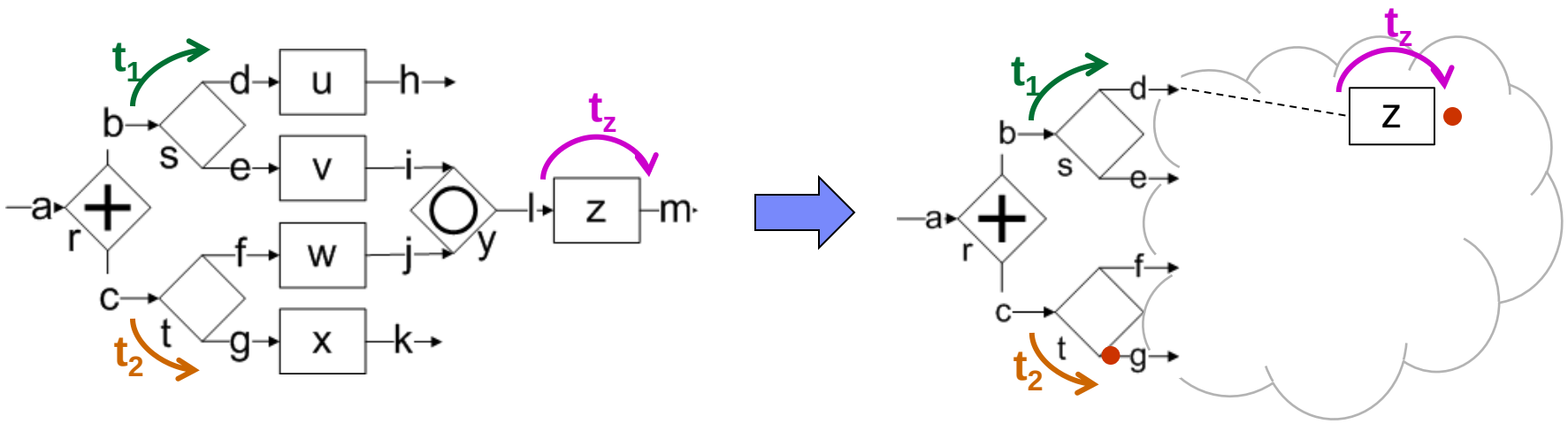

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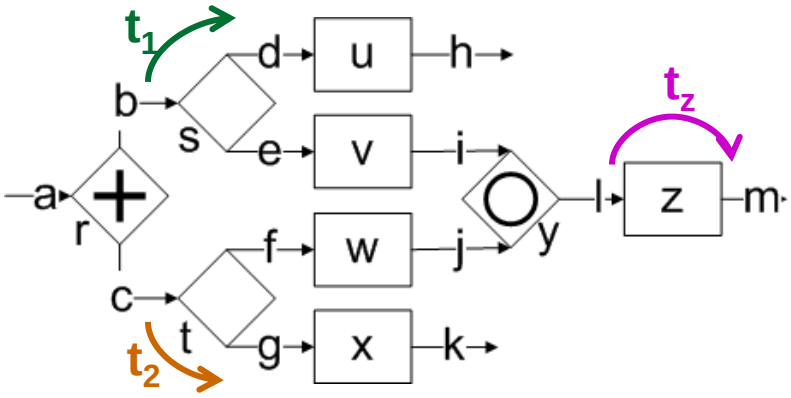
    → **there is a path from t_1 to t_z in the completion**
    → **this path can be executed**
  - **There is no execution executing t_1, t_2, and t_z**

Conclusions from this example



- For any notion of equivalence which implies the conservation of the execution properties
  - There exist executions where t_1 and t_z execute and, in executions where t_1 and t_z are executed, t_1 always executes before t_z
  - There is no execution executing t_1, t_2, and t_z

- The prefix cannot be completed:
  - The synchronization role played by an IOR-join cannot, in general, be implemented using XOR and AND gateways

Summary

- Contributions:
  - For acyclic processes
    - Characterization of IOR-joins that can be replaced locally and a local replacement technique
    - A non-local replacement technique with its condition of applicability which run in polynomial time
  - Show that a simple processes contains an IOR-join which synchronization role cannot be replaced by XOR and AND logic

- For some use cases, we have to be careful when we want to apply Petri net based analysis techniques to models that might contain an IOR-join