Dynamic Synthesis of Local Time Requirement for Service Composition

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Outline

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  - Service Composition
  - Global/Local Time Requirement
- Problem Statement
- Model of the System Composition
  - And/Or Labeled Transition System (AOLTS)
- Dynamic Synthesis of Local Time Requirement
- Conclusion

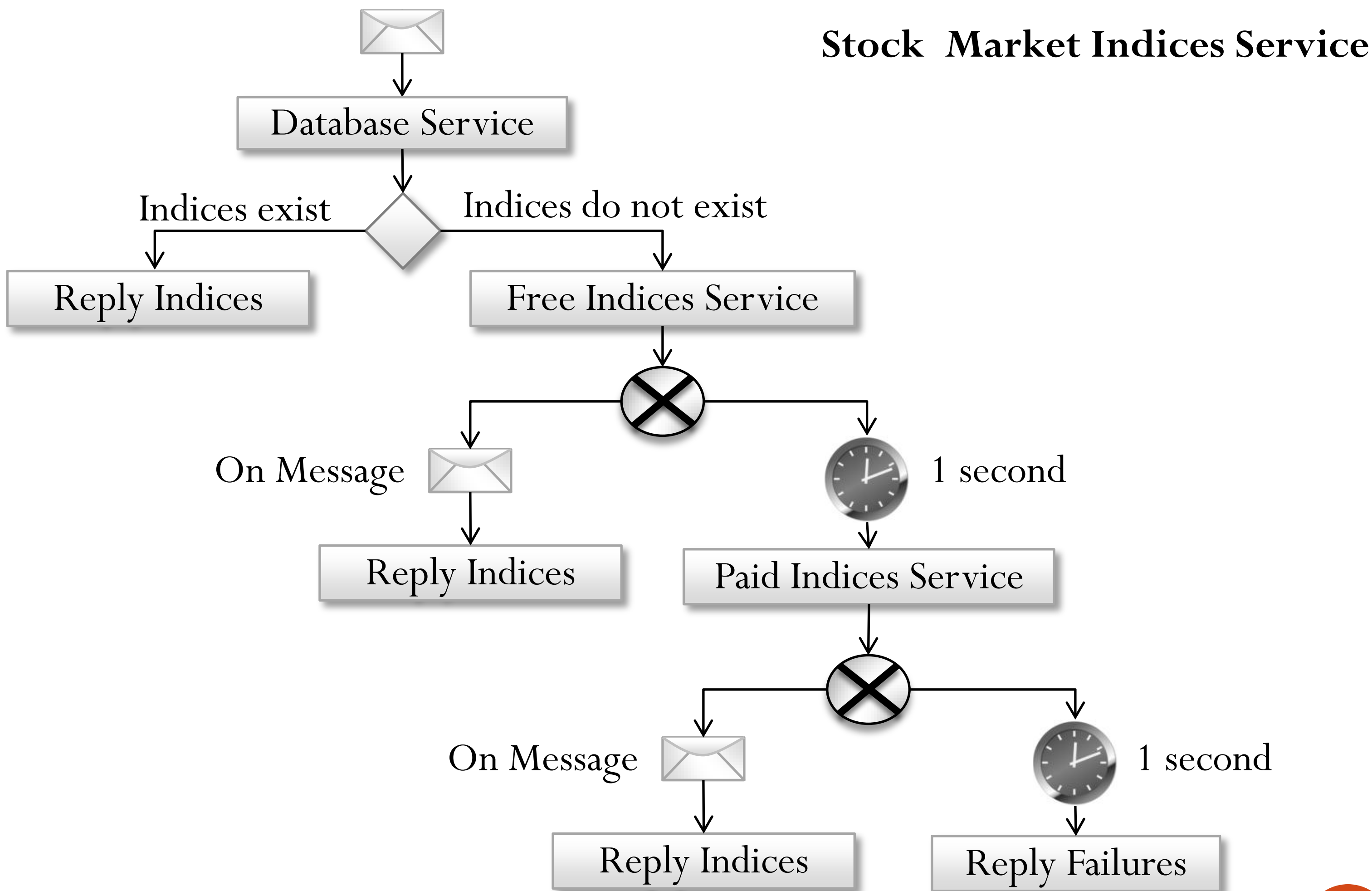
Motivation

Introduction –
What is Service Composition?

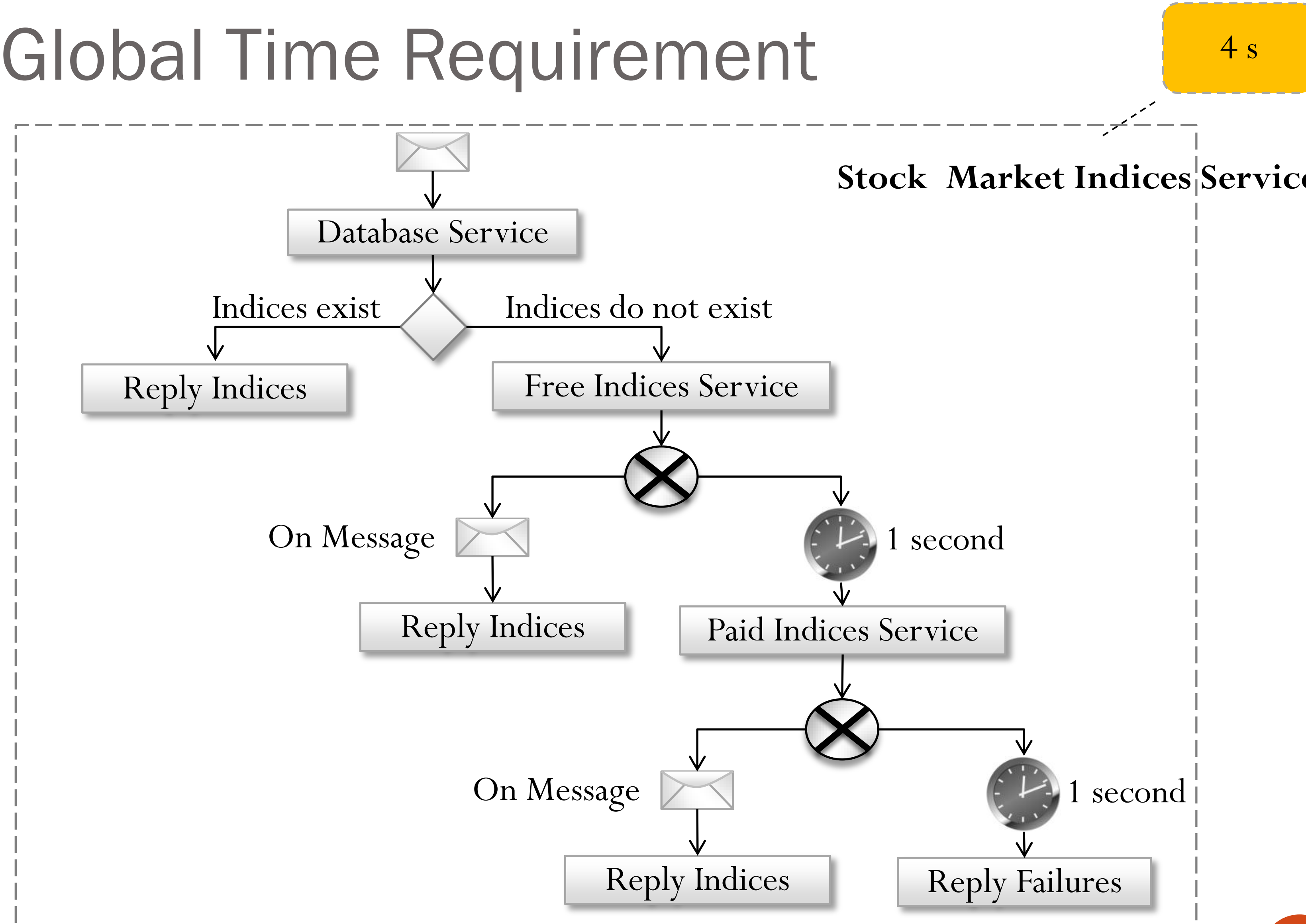
- A service composition makes use of existing service-based application as components to achieve a business goal, we denote the service that makes use of service composition as **composite service**.
- We denote the service that is made use by the composite service as **component service.**

Introduction –

What is Service Composition?

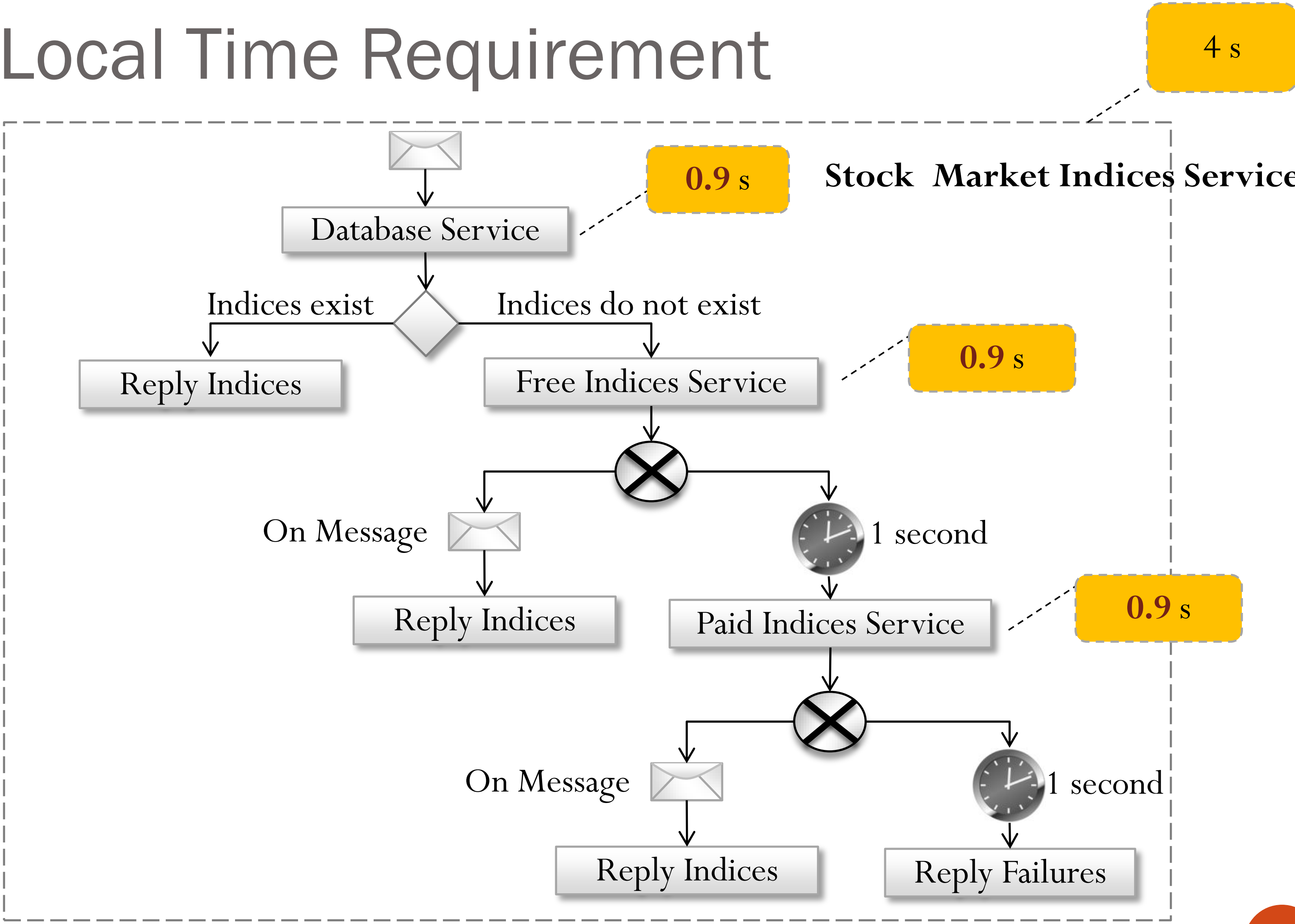


Introduction – Global Time Requirement



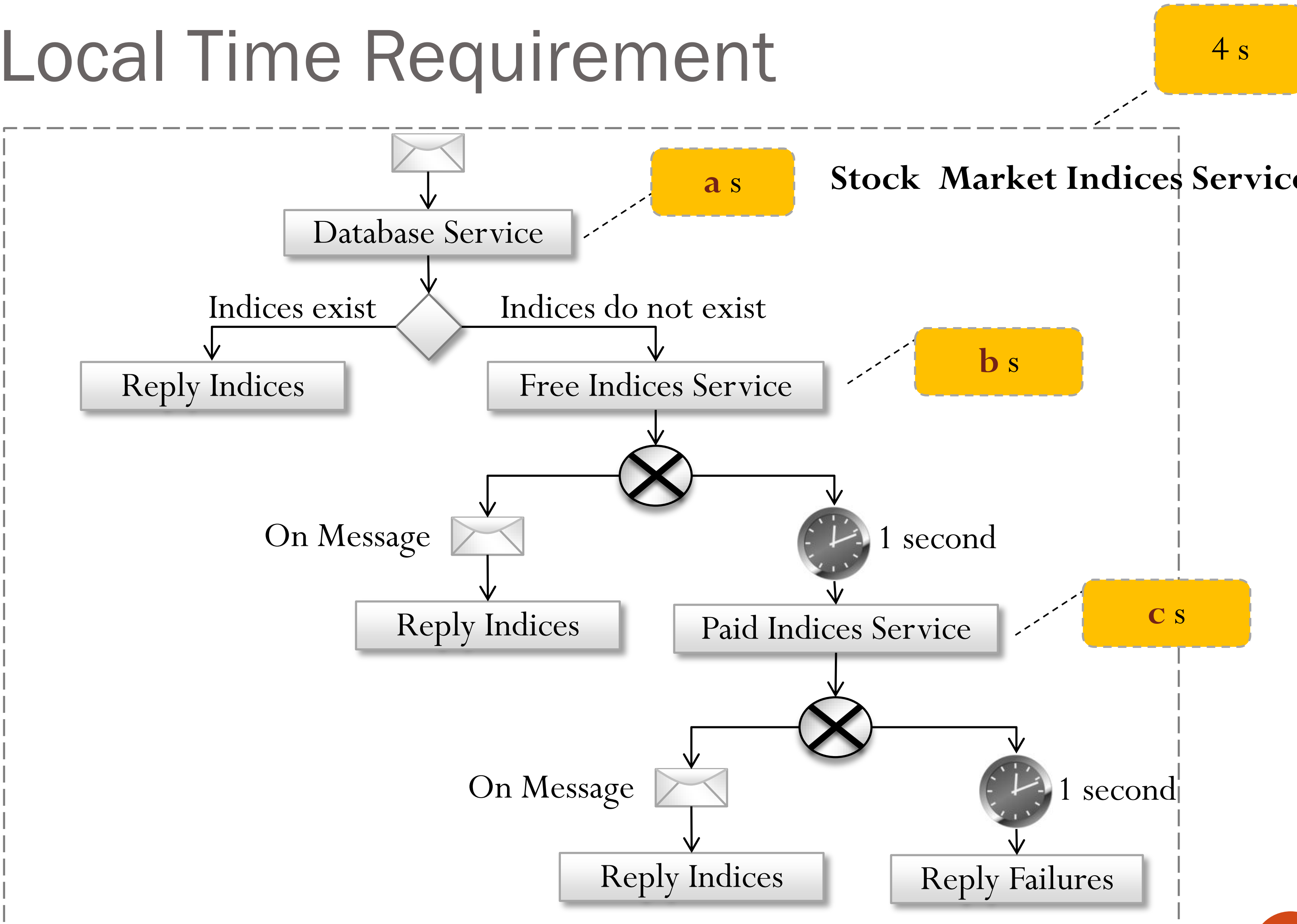
Introduction –

Local Time Requirement



There are infinite possibilities values of **a,b,..** , where **a,b,..** are real numbers.

Introduction –
Local Time Requirement



There are infinite possibilities values of **a,b,..** , where **a,b,..** are real numbers.

Introduction –
Tackle the infiniteness – reason parametrically

- Consider response times as parameters.
- Two component services, flight service (fs) and hotel service (hs),

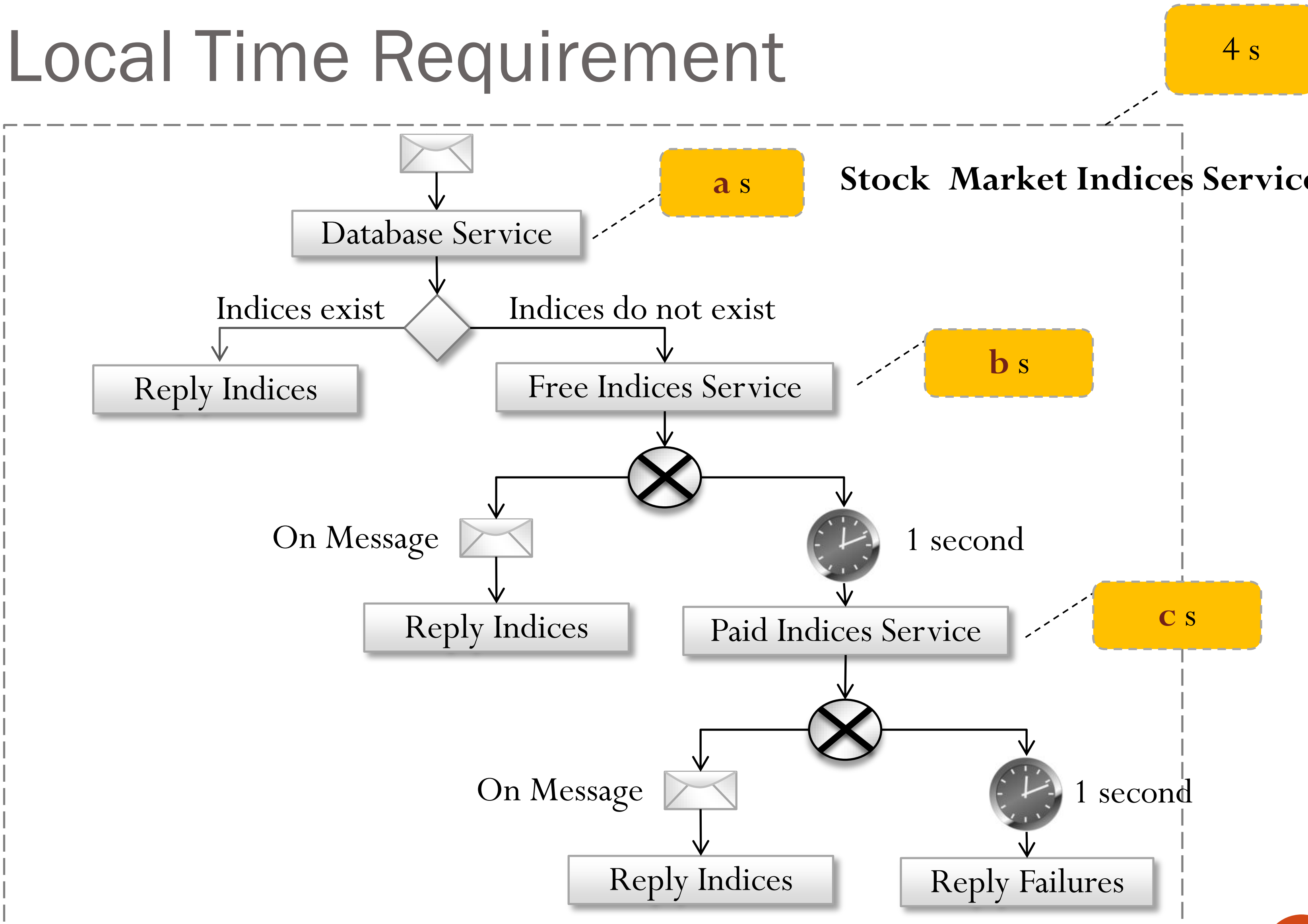
  {fs=1,hs=2},

  {fs=1.5,hs=1.5},

  …
- To reason about the infiniteness, we can reason parametrically.
- Make the response times as parameters t_{fs} and t_{hs}, use constraints on the parameters,

  e.g. $t_{fs} + t_{hs} <= 3$

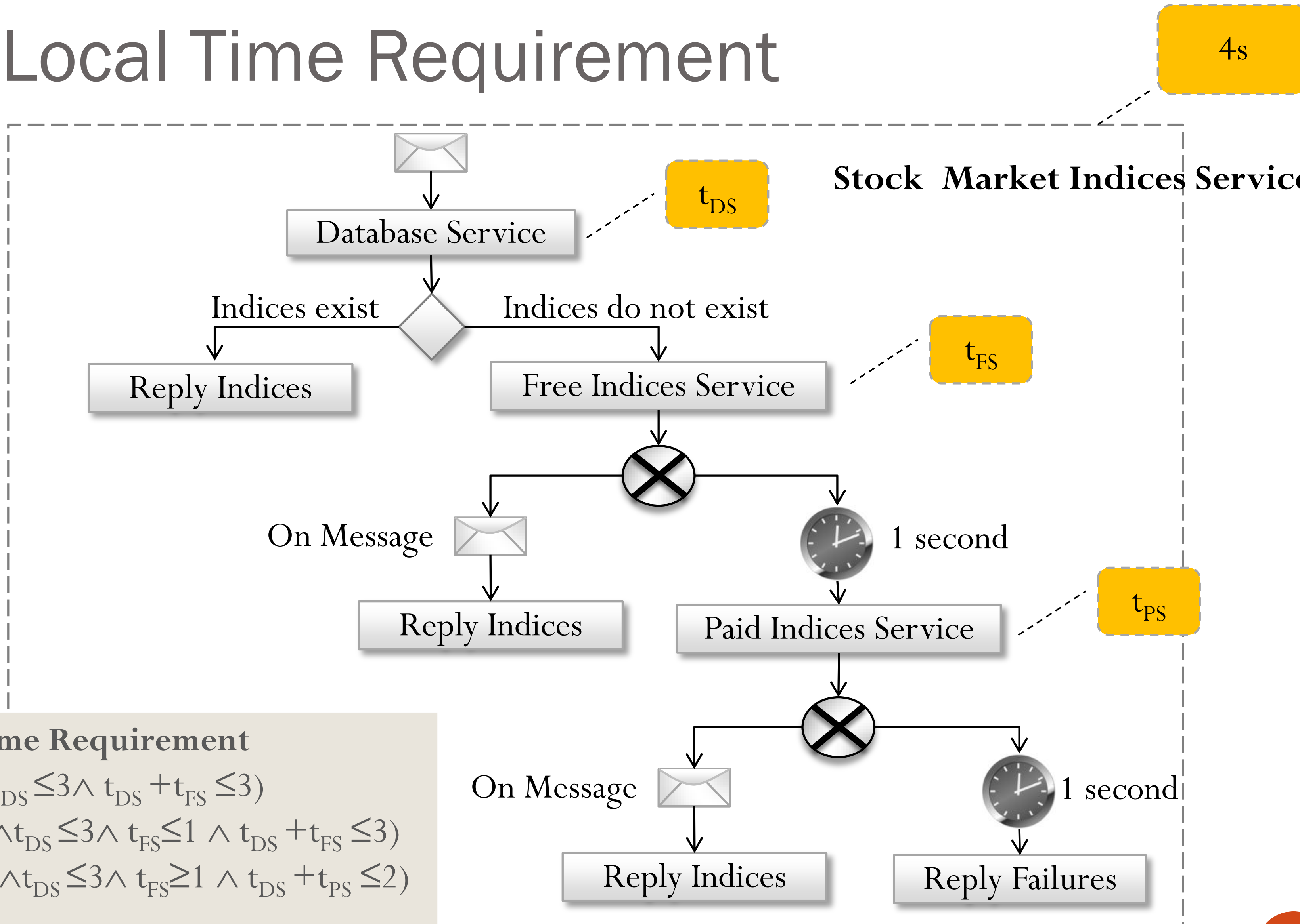
Introduction – Local Time Requirement



There are infinite possibilities values of **a,b,..** , where **a,b,..** are real numbers.

Introduction –

Local Time Requirement



Local Time Requirement

$(t_{FS}<1 \wedge t_{DS} \leq 3 \wedge t_{DS}+t_{FS} \leq 3)$

$\vee(t_{PS}<1 \wedge t_{DS} \leq 3 \wedge t_{FS} \leq 1 \wedge t_{DS}+t_{FS} \leq 3)$

$\vee(t_{PS}<1 \wedge t_{DS} \leq 3 \wedge t_{FS} \geq 1 \wedge t_{DS}+t_{PS} \leq 2)$

Problem Statement

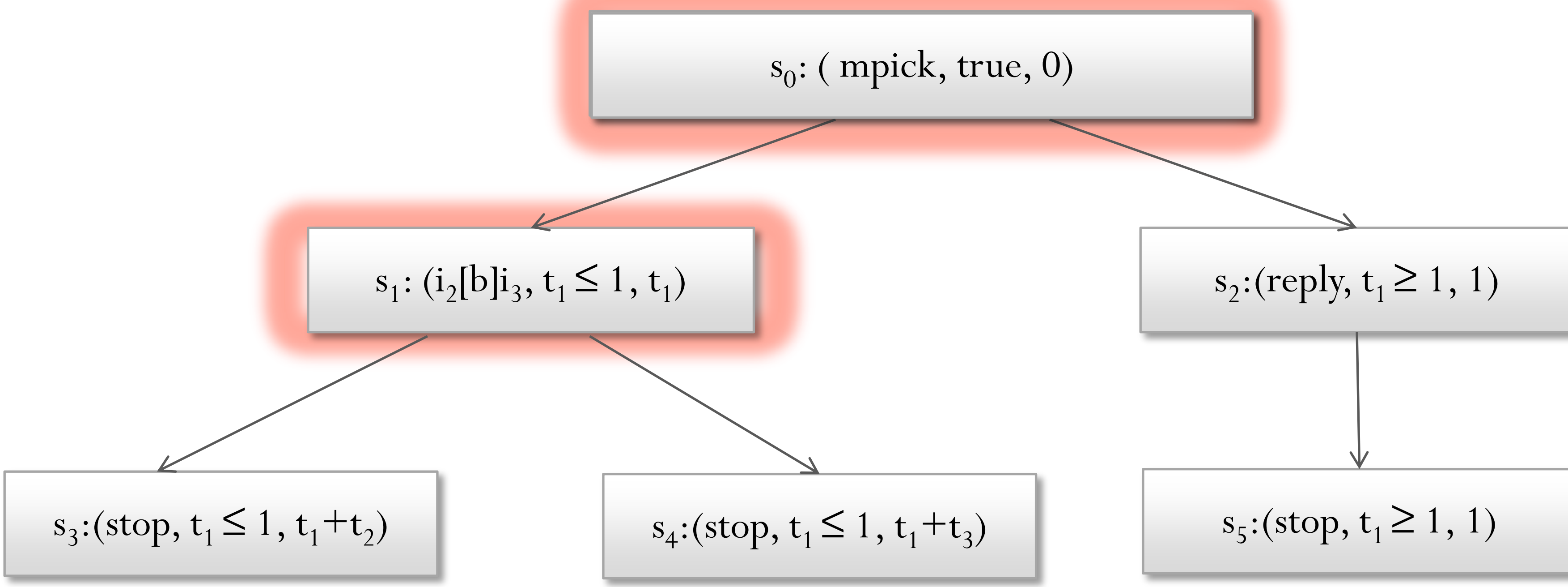
Given the global time requirement, synthesize local time requirement in constraint format using fully automated method.

Model of the System Composition - BPEL Syntax

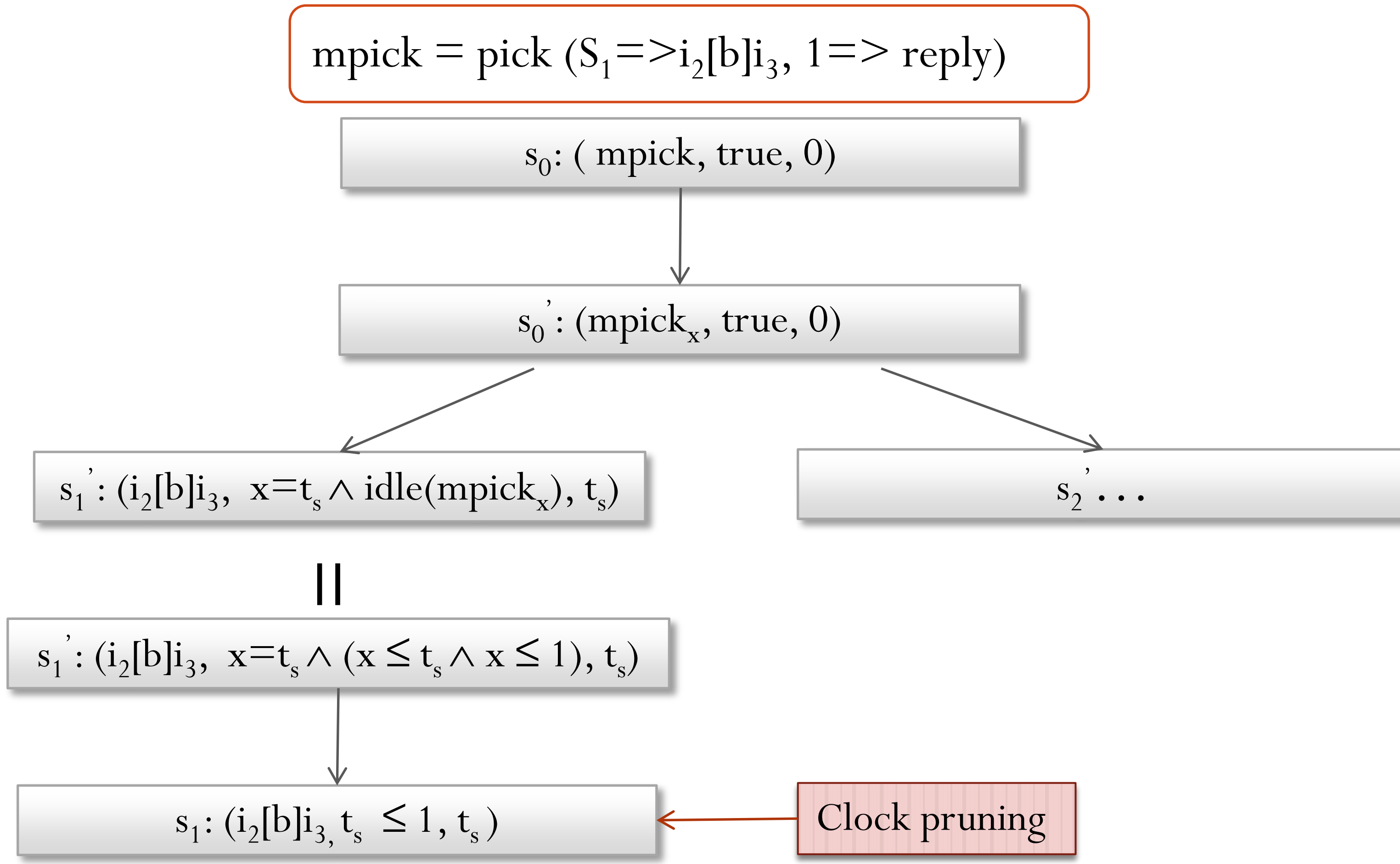
- ***rec*(S)** : receive from a service S
- ***reply*(S)**: reply to a service S
- ***sInv*(S)**(***aInv*(S)**): synchronous (asynchronous) invocation of a service S
- **P|||Q**: concurrent execution of P and Q
- **P[b]Q**: conditional activity, where b is a guard condition. If b is evaluated as true, P is executed, otherwise, Q is executed.
- ***pick*(S=>P, *alrm(a)* =>Q)**: <pick> activity, where either receives the message from service S within a seconds, or timeouts at *a* seconds.

Model of the System Composition - LTS of Service P

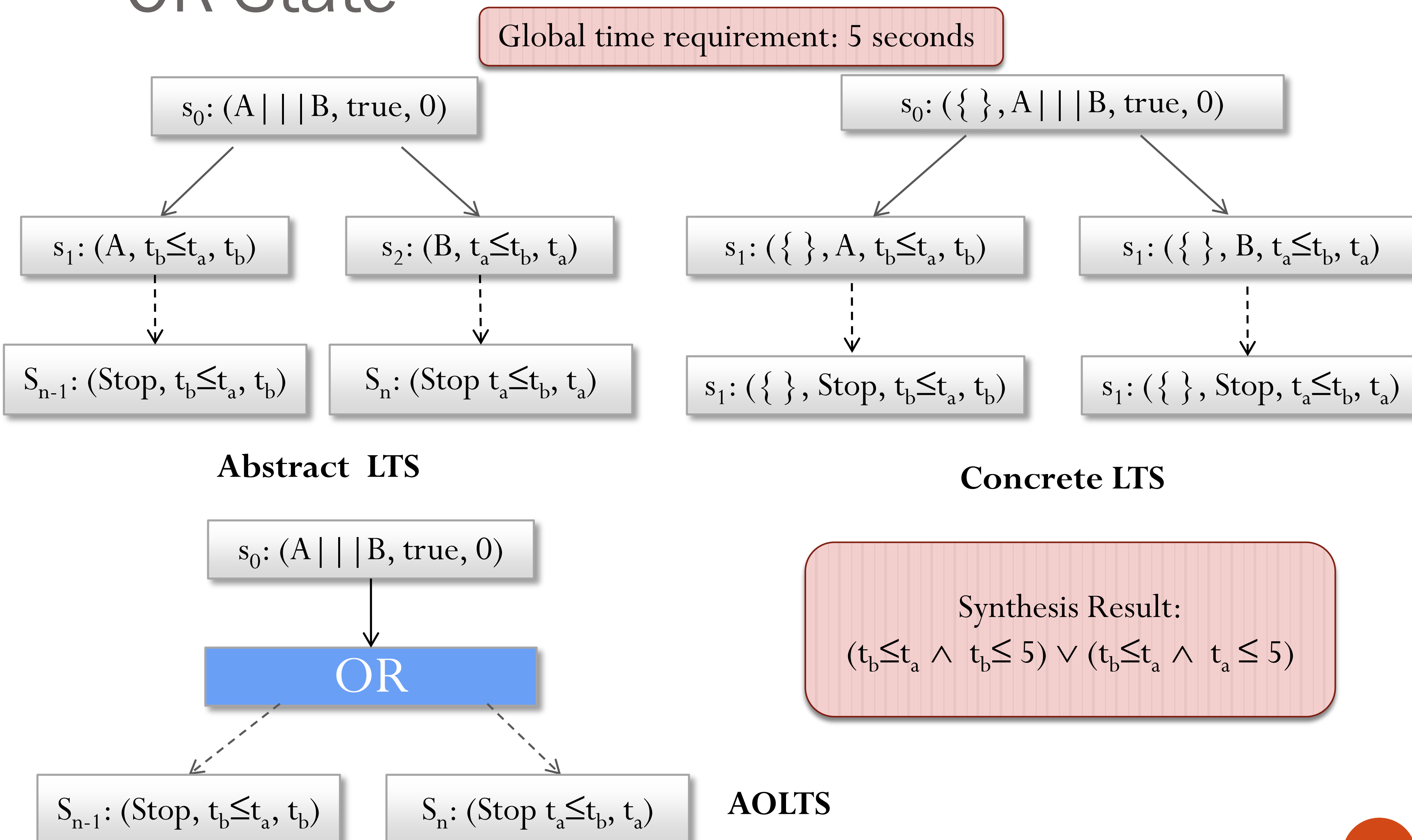
mpick = pick (S_1=>i_2[b]i_3, 1=> reply)



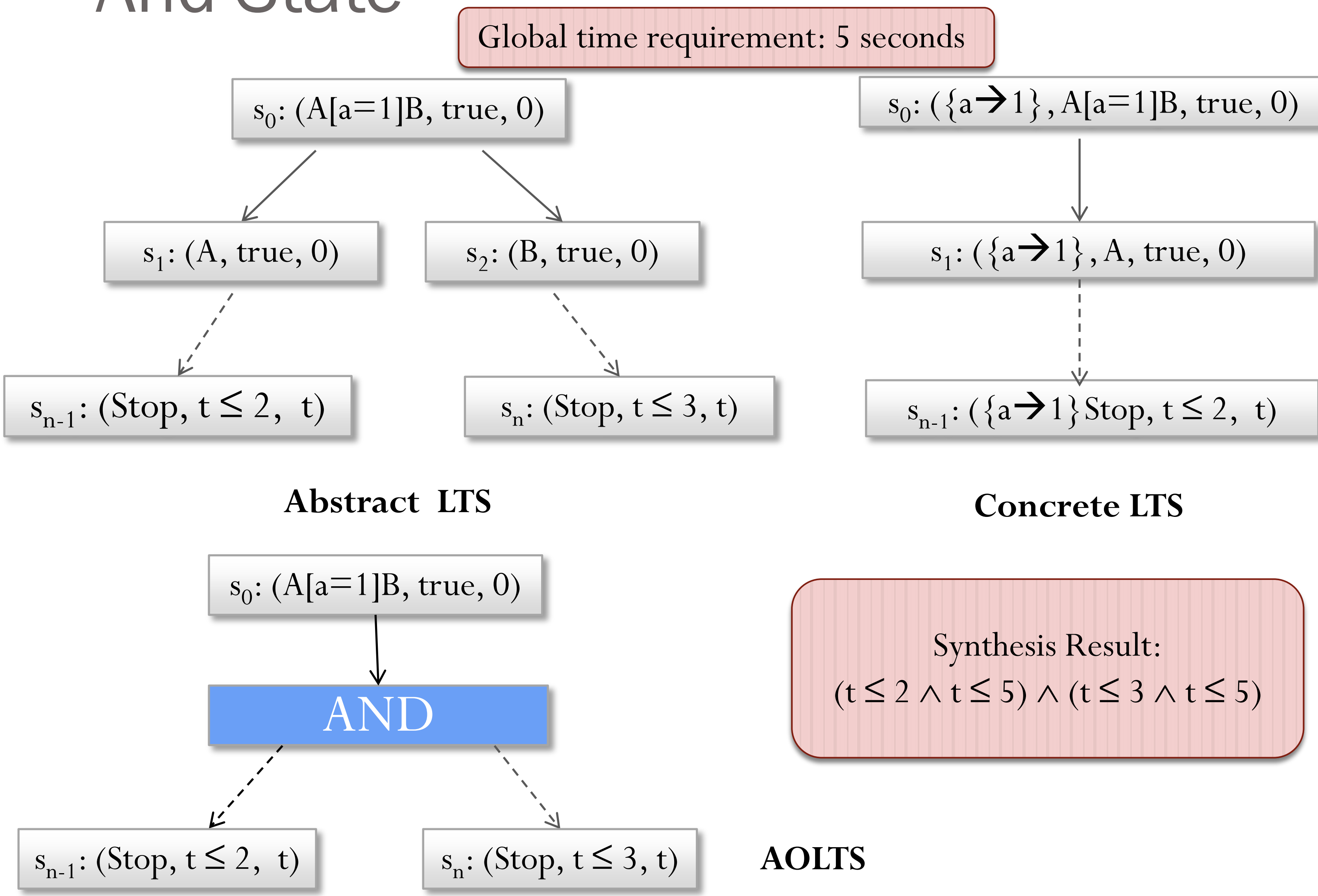
Model of the System Composition - Calculating the constraint



Model of the System Composition – OR State

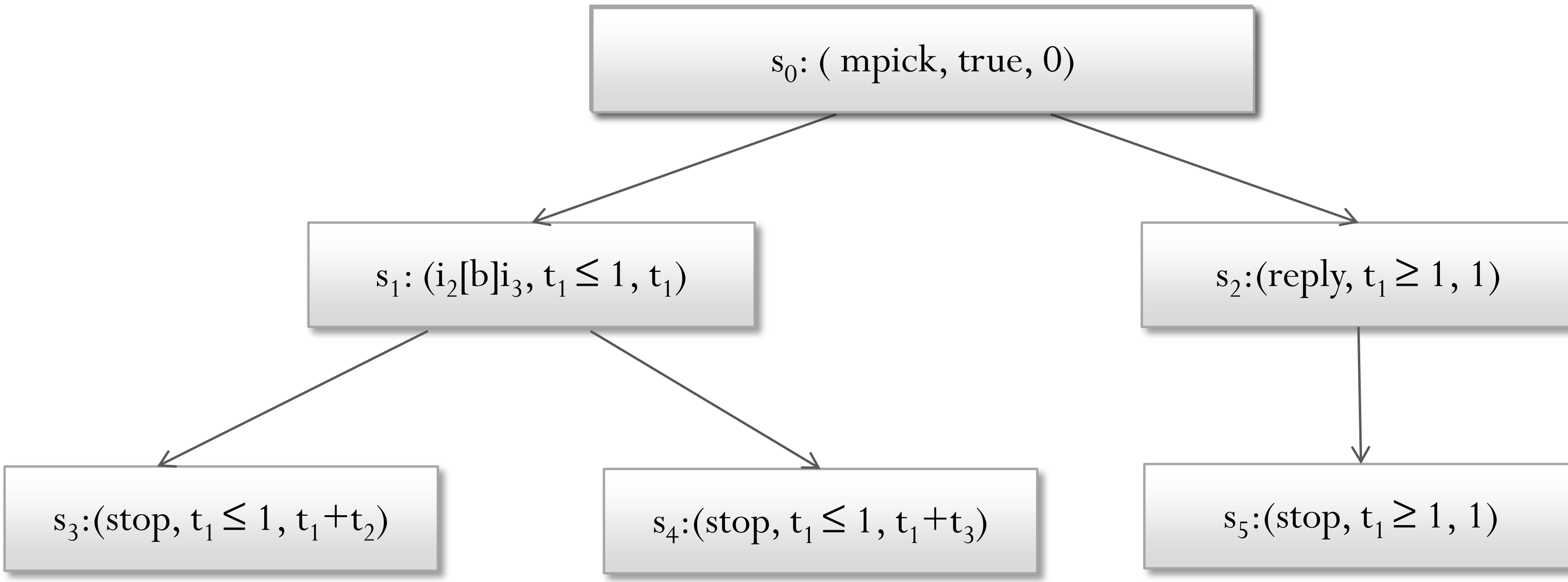


Model of the System Composition – And State

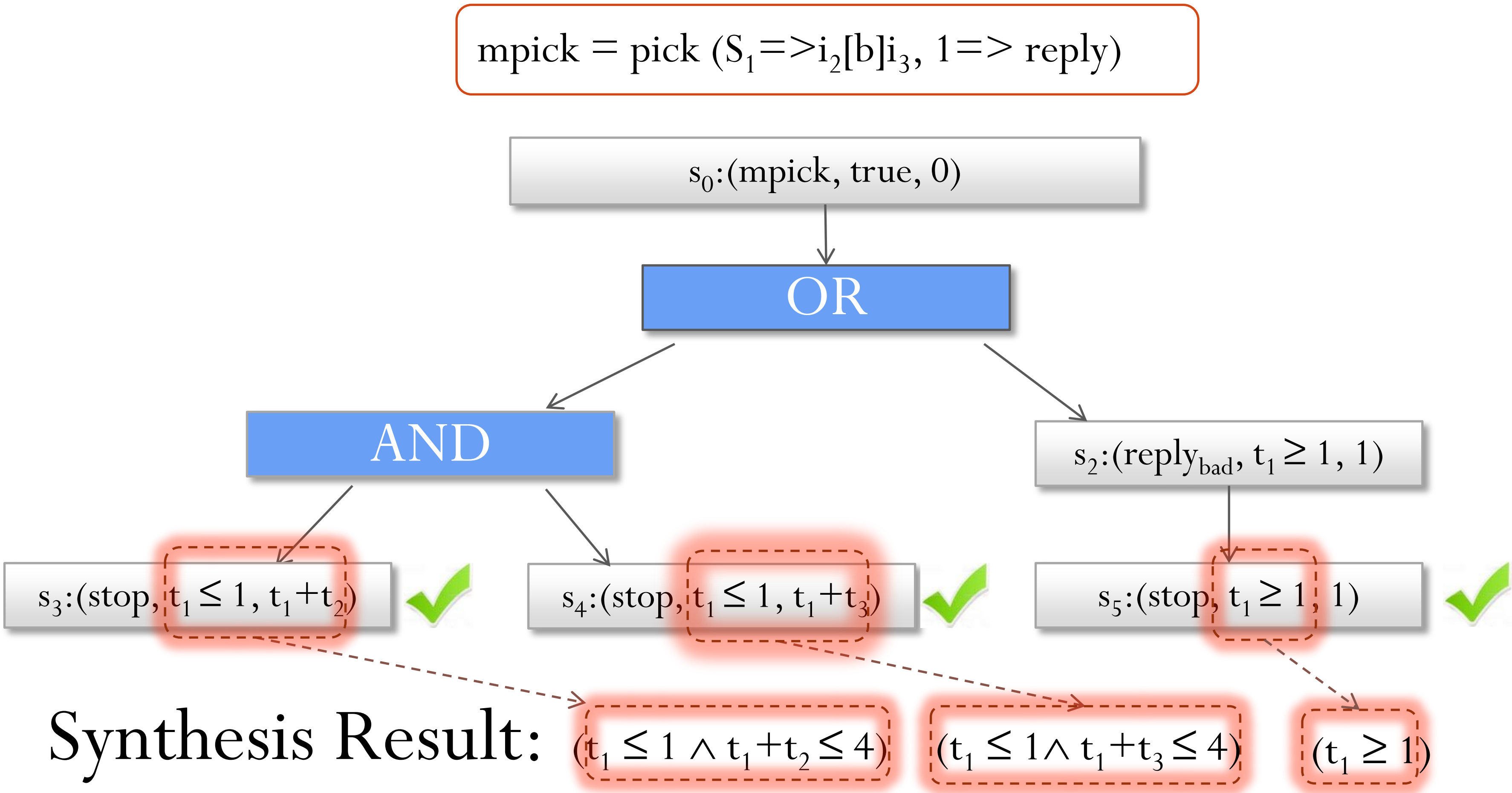


Model of the System Composition - LTS of Service P

mpick = pick (S_1=>i_2[b]i_3, 1=> reply)

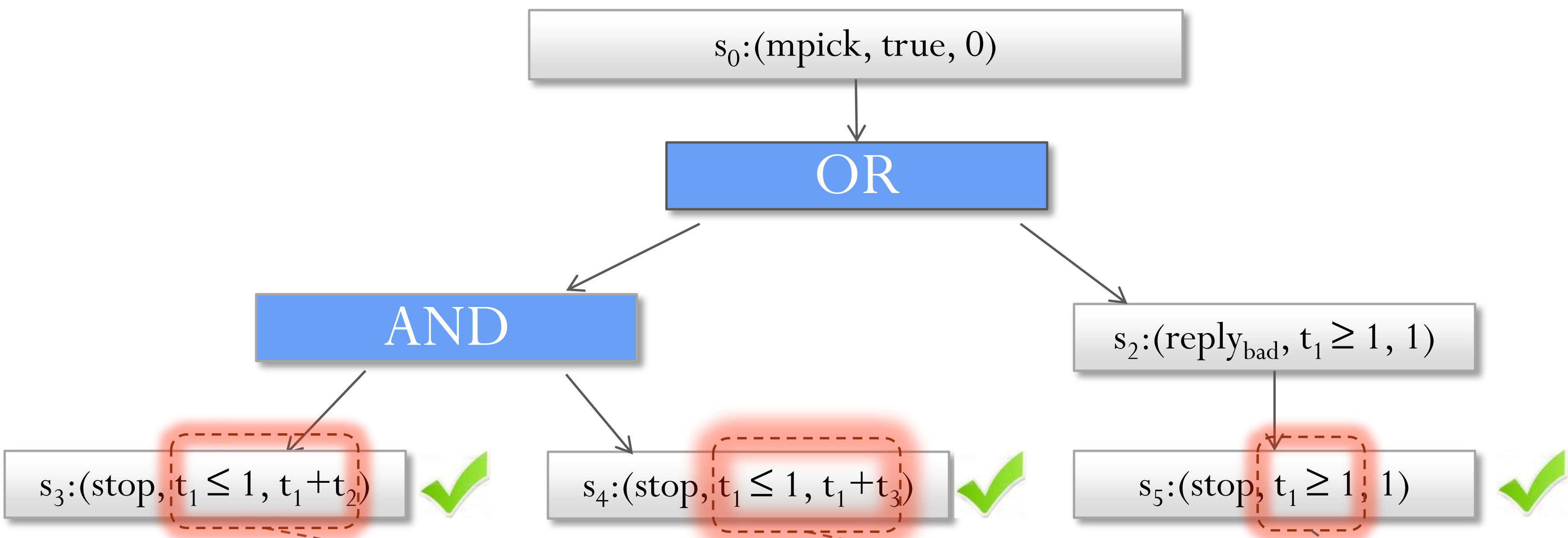


Model of the System Composition - AOLTS LTS of Service P



Model of the System Composition - AOLTS LTS of Service P

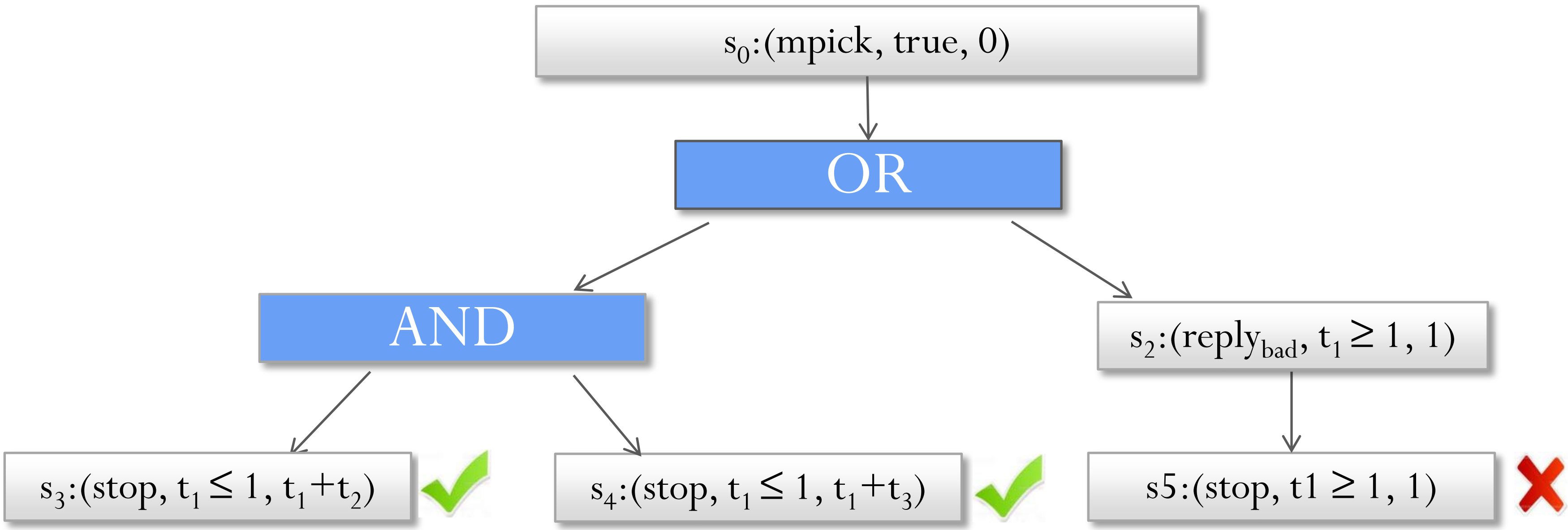
$mpick = pick\ (S_1 \Rightarrow i_2[b]i_3,\ 1 \Rightarrow reply)$



Synthesis Result: $((t_1 \le 1 \wedge t_1+t_2 \le 4) \wedge (t_1 \le 1 \wedge t_1+t_3 \le 4)) \vee (t_1 \ge 1)$

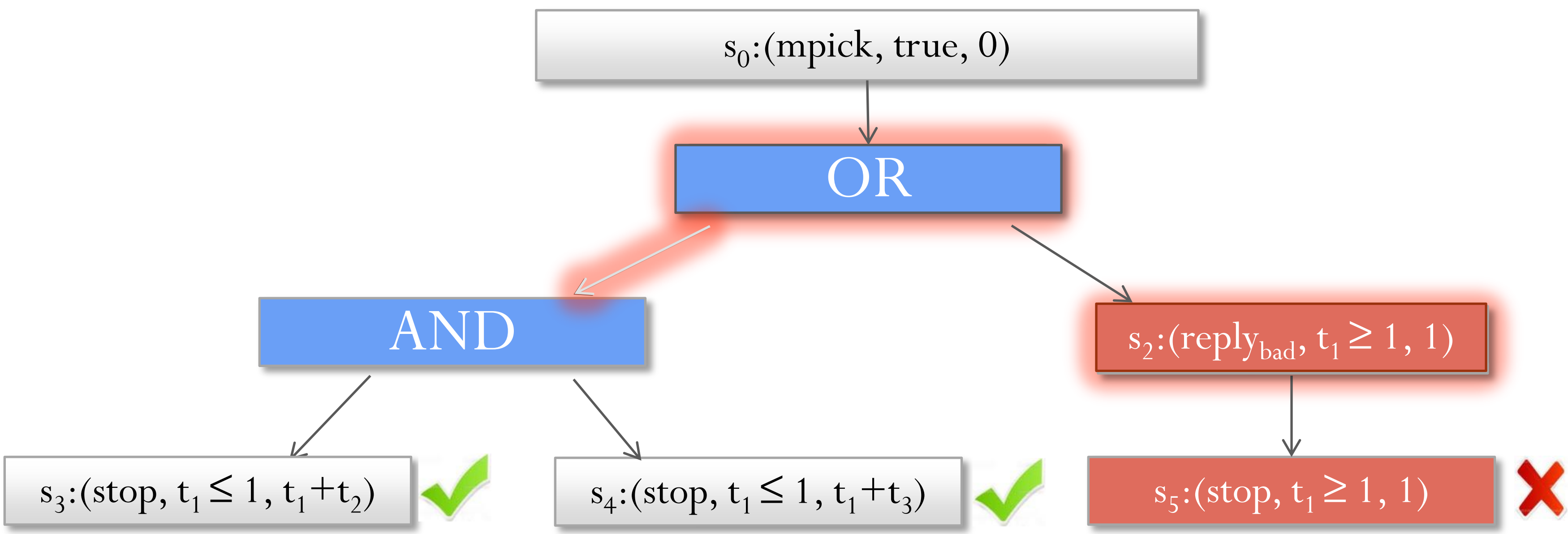
Dynamic Synthesis of Local Time Requirement - Bad State

$$mpick = pick\ (S_1 \Rightarrow i_2[b]i_3,\ 1 \Rightarrow [reply]_{bad})$$



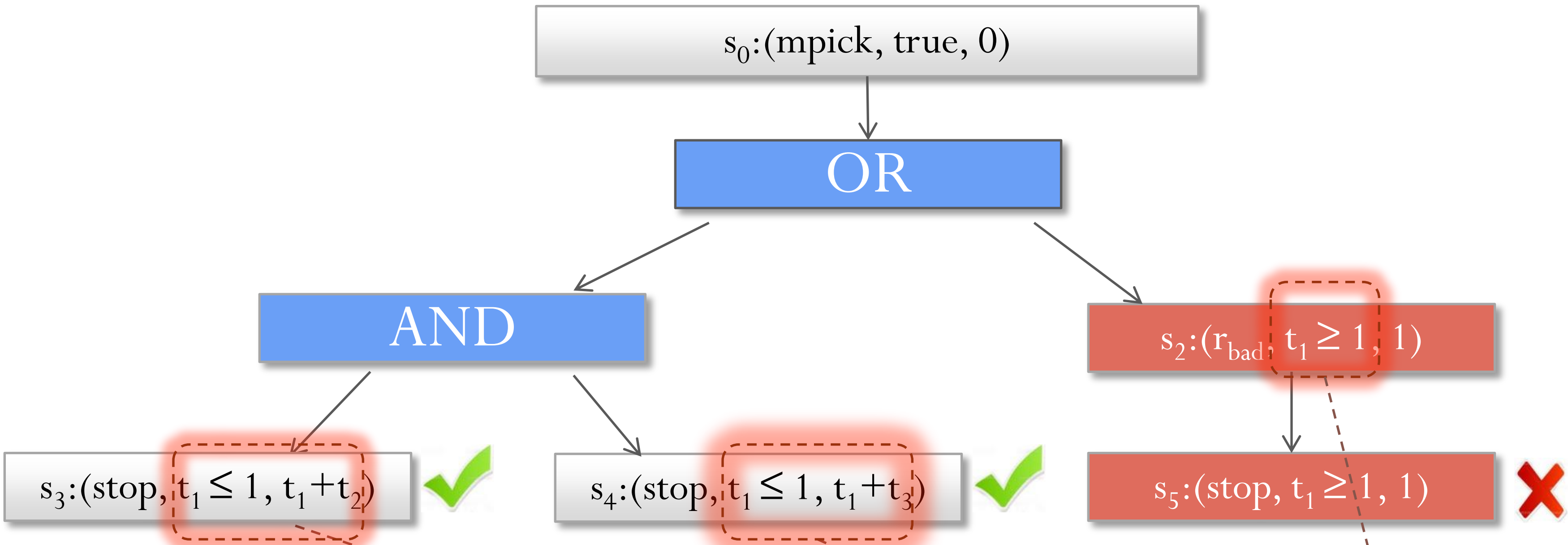
Dynamic Synthesis of Local Time Requirement - Bad State Propagation

mpick = pick (S_1=>i_2[b]i_3, 1=> $[\text{reply}]_{bad}$)



Dynamic Synthesis of Local Time Requirement -

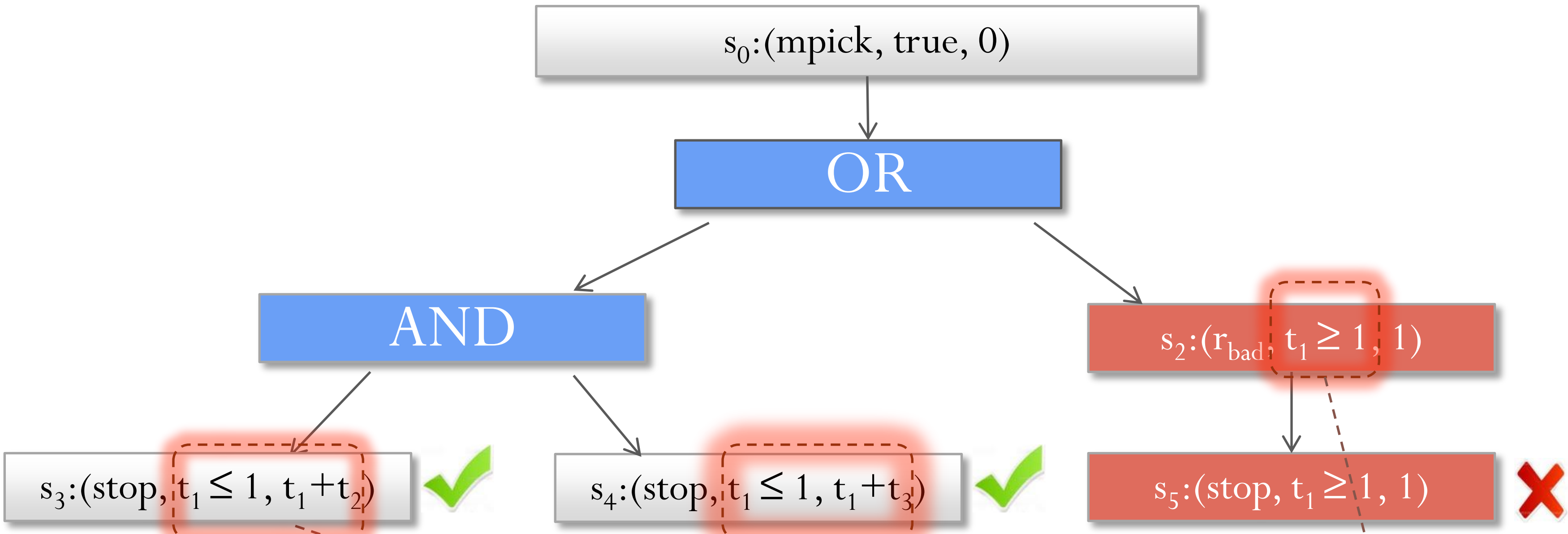
Synthesize constraint



Synthesis Result: $(t_1 \leq 1 \wedge t_1+t_2 \leq 4)$ $(t_1 \leq 1 \wedge t_1+t_3 \leq 4)$ $\neg (t_1 \geq 1)$

Dynamic Synthesis of Local Time Requirement -

Synthesize constraint



Synthesis Result: $(t_1 \leq 1 \wedge t_1+t_2 \leq 4) \wedge (t_1 \leq 1 \wedge t_1+t_3 \leq 4) \wedge \neg (t_1 \geq 1)$

$$= \ t_1 < 1 \wedge t_1+t_2 \leq 4 \wedge t_1+t_3 \leq 4$$

Implementation and Evaluation

- Tools:
  PPL - calculate the performs the constraint and clock pruning
  Z3 – To simplify the formula and checking the satisfiability of the formula
- Applying the method to two case studies
  - Computer Purchasing Service
  - Travel Booking Service

Evaluation-
Computer Purchasing Service
(e.g., Dell.com)

(State=457, Transition=6355, 2 seconds)

$$
\begin{aligned}
& (t_{SS}+t_{LS}\leq t_{IS})\wedge(t_{IS}\leq t_{BS})\wedge(t_{SS}+t_{LS}+t_{IS}+t_{BS}\leq 3)\\
\vee\ & (t_{SS}+t_{LS}\leq t_{BS})\wedge(t_{BS}\leq t_{IS})\wedge(t_{SS}+t_{LS}+t_{IS}+t_{BS}\leq 3)\\
\vee\ & (t_{SS}+t_{LS}\leq t_{BS})\wedge(t_{SS}\leq t_{IS})\wedge(t_{IS}\leq t_{SS}+t_{LS})\wedge(t_{SS}+t_{LS}+t_{IS}+t_{BS}\leq 3)\\
\vee\ & (t_{SS}\leq t_{IS})\wedge(t_{IS}\leq t_{BS})\wedge(t_{BS}\leq t_{SS}+t_{LS})\wedge(t_{SS}+t_{LS}+t_{IS}+t_{BS}\leq 3)\\
\vee\ & (t_{SS}+t_{LS}\leq t_{IS})\wedge(t_{SS}\leq t_{BS})\wedge(t_{BS}\leq t_{SS}+t_{LS})\wedge(t_{SS}+t_{LS}+t_{IS}+t_{BS}\leq 3)\\
\vee\ & (t_{SS}\leq t_{BS})\wedge(t_{BS}\leq t_{IS})\wedge(t_{IS}\leq t_{SS}+t_{LS})\wedge(t_{SS}+t_{LS}+t_{IS}+t_{BS}\leq 3)\\
\vee\ & (t_{SS}+t_{LS}\leq t_{BS})\wedge(t_{IS}\leq t_{SS})\wedge(t_{SS}+t_{LS}+t_{IS}+t_{BS}\leq 3)\\
\vee\ & (t_{SS}\leq t_{BS})\wedge(t_{IS}\leq t_{BS})\wedge(t_{BS}\leq t_{SS}+t_{LS})\wedge(t_{SS}+t_{LS}+t_{IS}+t_{BS}\leq 3)\\
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\vee\ & (t_{SS}+t_{LS}\leq t_{IS})\wedge(t_{BS}\leq t_{SS})\wedge(t_{SS}+t_{LS}+t_{IS}+t_{BS}\leq 3)\\
\vee\ & (t_{SS}\leq t_{IS})\wedge(t_{BS}\leq t_{SS})\wedge(t_{IS}\leq t_{SS}+t_{LS})\wedge(t_{SS}+t_{LS}+t_{IS}+t_{BS}\leq 3)\\
\vee\ & (t_{IS}\leq t_{SS})\wedge(t_{BS}\leq t_{IS})\wedge(t_{SS}+t_{LS}+t_{IS}+t_{BS}\leq 3)
\end{aligned}
$$

Evaluation- Travel Booking Service (e.g., Zuji.com)

(State=705, Transition=3412, 1.5 seconds)

$$
\begin{aligned}
& (t_{HSbak}<1)\wedge(t_{FSbak}<1)\wedge(t_{FS}\leq 2)\wedge(t_{HS}\geq 2) \\
\vee\ & (t_{FS}\leq 2t_{HS})\wedge(t_{HSbak}<1)\wedge(t_{FSbak}1)\wedge(t_{FS}\leq 2)\wedge(t_{HS}\leq 2) \\
\vee\ & ((t_{FSbak}\leq 2t_{HSbak})\wedge(t_{HSbak}<1)\wedge(t_{FSbak}<1)\wedge(t_{HS}\geq 2)\wedge(t_{FS}\geq 2) \\
& \wedge(t_{FSbak}+t_{HSbak}\leq 1)) \\
\vee\ & ((t_{HSbak}\leq 2t_{FSbak})\wedge(t_{HSbak}<1)\wedge(t_{FSbak}<1)\wedge(t_{HS}\geq 2)\wedge(t_{FS}\geq 2) \\
& \wedge(t_{FSbak}+t_{HSbak}\leq 1)) \\
\vee\ & (t_{HSbak}<1)\wedge(t_{FSbak}<1)\wedge(t_{HS}\leq 2)\wedge(t_{FS}\geq 2) \\
\vee\ & (t_{HS}\leq 2t_{FS})\wedge(t_{HSbak}<1)\wedge(t_{FSbak}<1)\wedge(t_{FS}\leq 2)\wedge(t_{HS}\leq 2) \\
\vee\ & (t_{HSbak}<1)\wedge(t_{FS}<2)\wedge(t_{HS}\geq 2) \\
\vee\ & (t_{FS}\leq 2t_{HS})\wedge(t_{HSbak}<1)\wedge(t_{FS}<2)\wedge(t_{HS}\leq 2) \\
\vee\ & (t_{HS}\leq 2t_{FS})\wedge(t_{HS}\leq 2)\wedge(t_{HSbak}<1)\wedge(t_{FS}<2) \\
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\vee\ & (t_{HS}<2)\wedge(t_{FS}\geq 2)\wedge(t_{FSbak}<1) \\
\vee\ & (t_{HS}\leq 2t_{FS})\wedge(t_{HS}<2)\wedge(t_{FS}\leq 2)\wedge(t_{FSbak}<1) \\
\vee\ & (t_{FS}\leq 2t_{HS})\wedge(t_{HS}<2)\wedge(t_{FS}\leq 2) \\
\vee\ & (t_{HS}\leq 2t_{FS})\wedge(t_{HS}<2)\wedge(t_{FS}\leq 2)
\end{aligned}
$$

Conclusion and Future Works

- A novel techniques has been proposed to synthesize the local time constraint for the component service.
- The approach is based on parametric timed techniques, based on AOLTS of the composite service.
- Future Work
  - Reduction of states and transition
  - Investigate combination of our approach to other approach to synthesize a better local time requirement
  - Extend to other domains of similar problems, e.g. Sensor Network

Thank you