An Approach for Estimating Performance and Energy Consumption in Component-Based Embedded Real-Time Systems

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Introduction

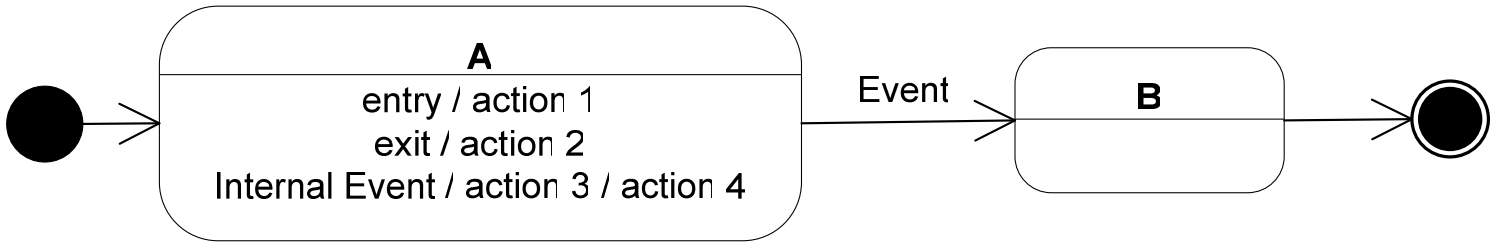
- Embedded systems are present in so many areas of our lives;
  - Stringent timing constraints;
  - Great concerns related to energy consumption.
- Components have become very common in the building of complex embedded real-time systems.
  - Fast development and reuse of embedded software applications.
- UML is used for system design;
- In real-time systems it is indispensable the description of quantitative system;
- These UML models themselves are not directly analyzable.

Objective

- Propose
  - the integration of formal performance models with semi-formal notations;
  - a method for mapping State Machine diagram into a Time Petri Net with Energy Consumption (ETPN).
  - in order to carry out estimating (energy consumption and execution time) and verification of embedded real-time system components.

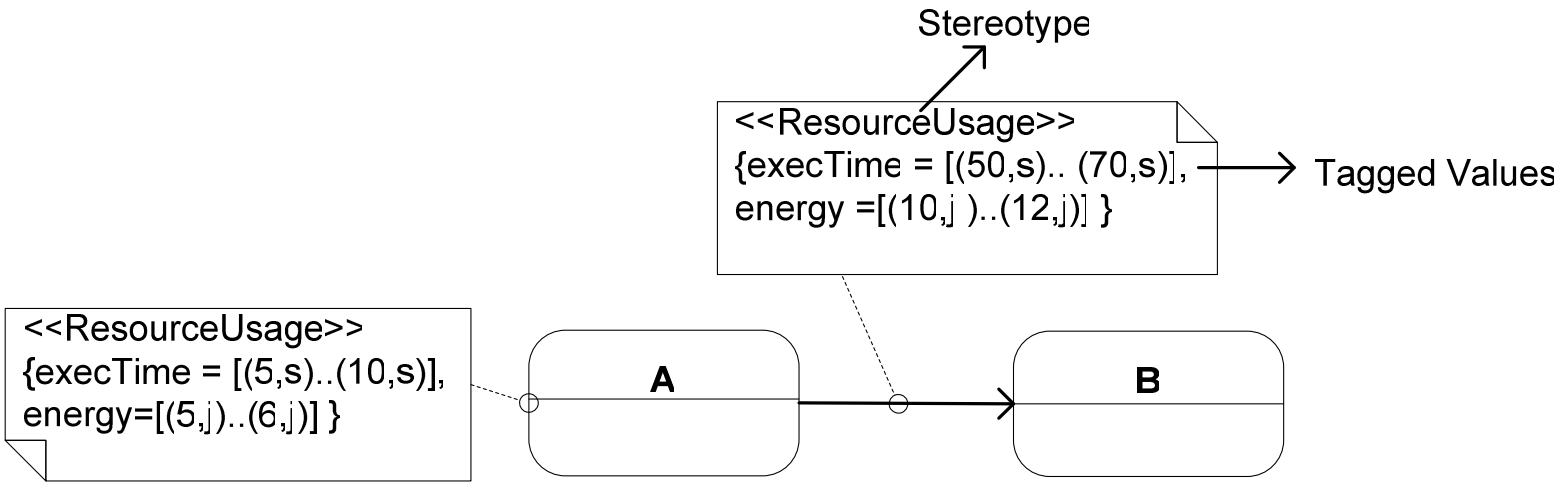
Background

- State Machine Diagram
  - Suitable characteristics for modeling requirement when dealing with real-time systems;
  - Used to specify the system behavior through possible sequences of reachable states in which an entity may proceed over its lifetime.



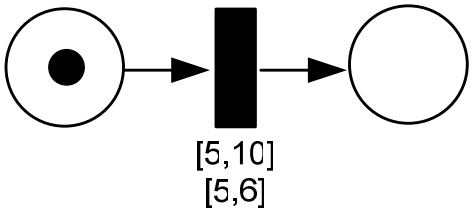
Background

- MARTE (Modeling and Analysis of Real-Time and Embedded systems)
  - Providing facilities to annotate models with information required to perform specific analysis.



Background

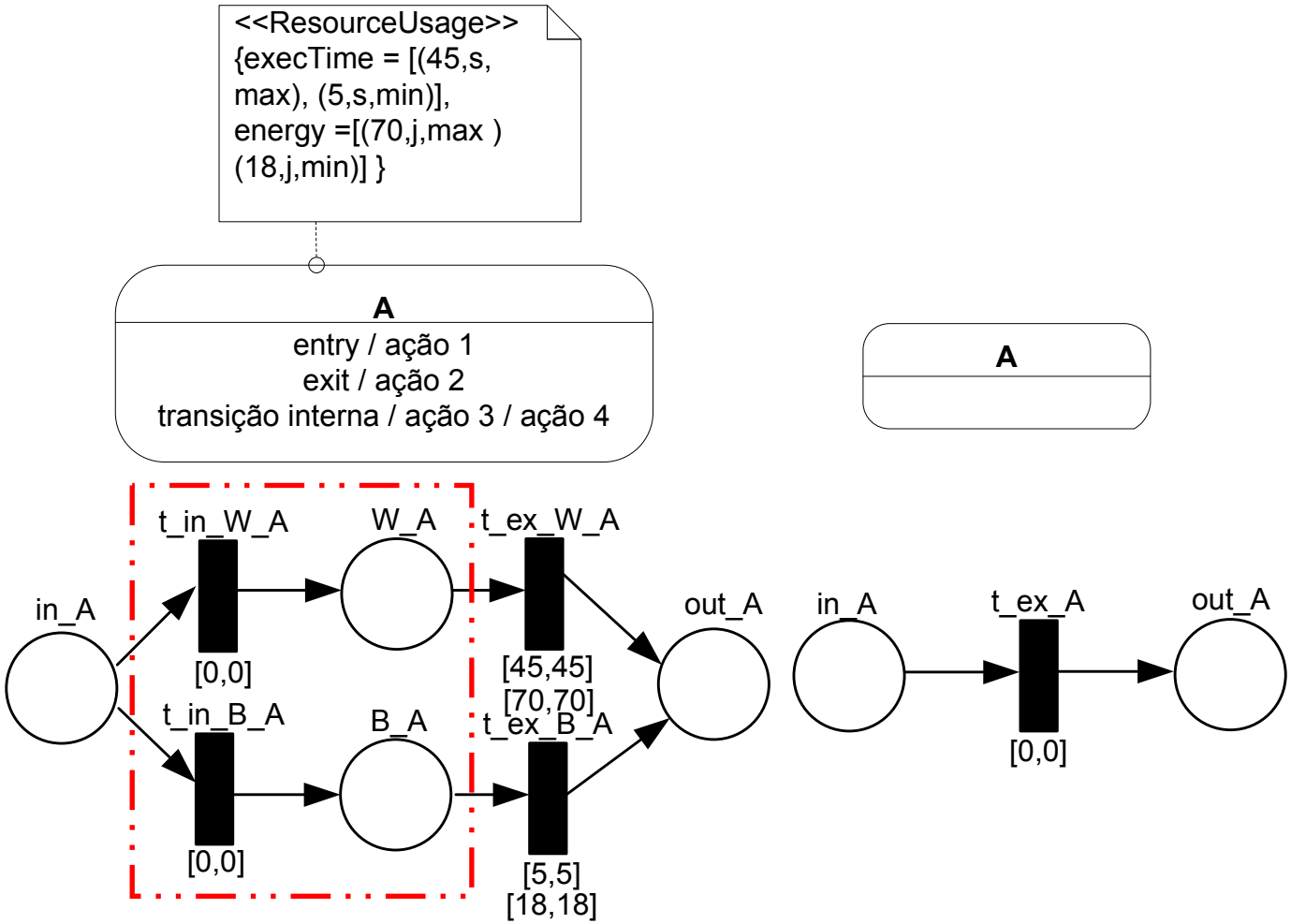
- Petri Net
  - Graphic and Mathematical modeling tool;
  - Applied in several types of systems:
    - Parallel, Concurrent, Asynchronous and Non-deterministic systems.
  - Many representations and extensions have been proposed.
    - Time Petri Net with Energy consumption (ETPN).



Strong Firing Semantics

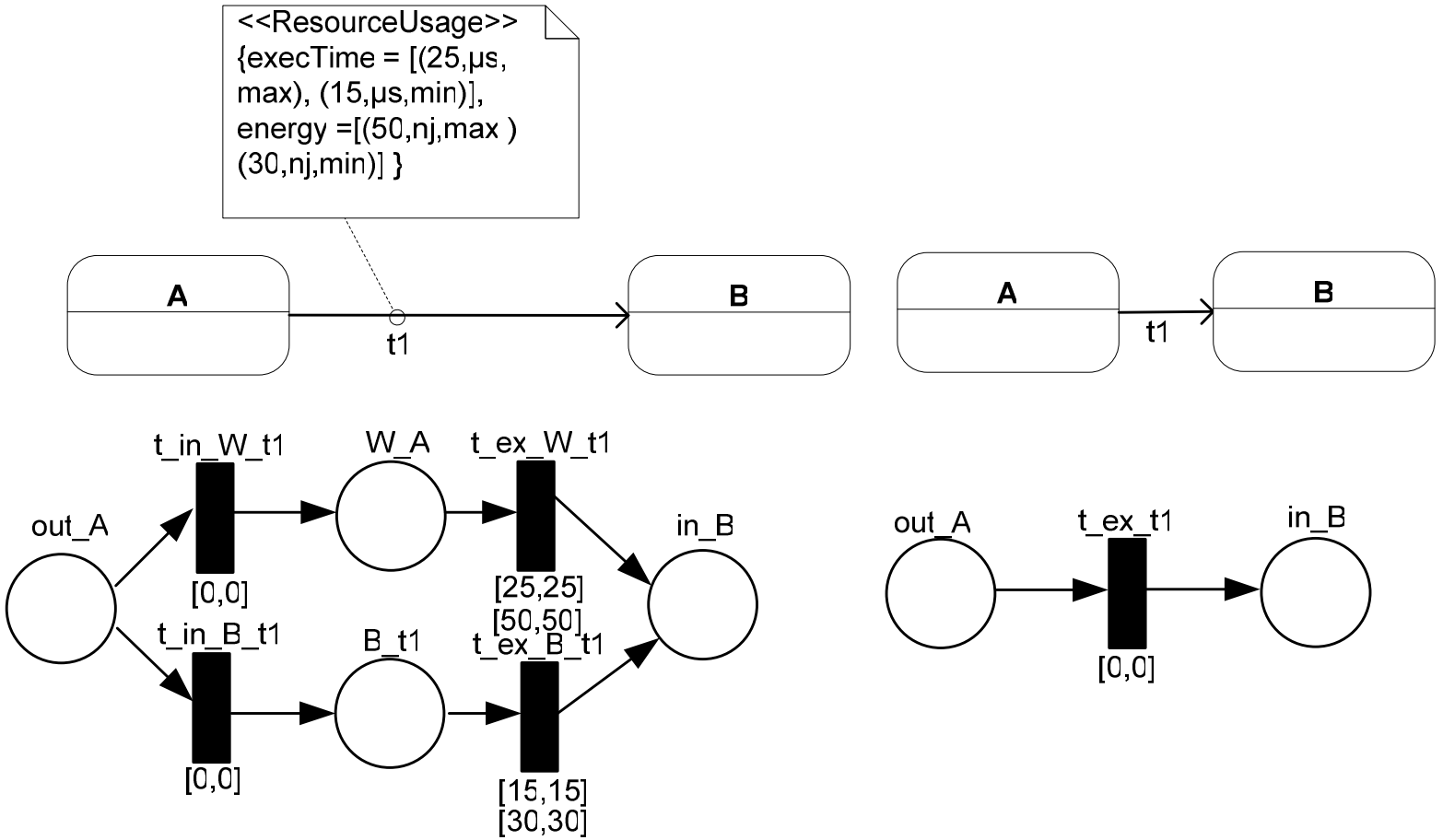
Mapping UML-SM into an ETPN

Translation



Strong Firing Semantics **Mapping States**

Translation



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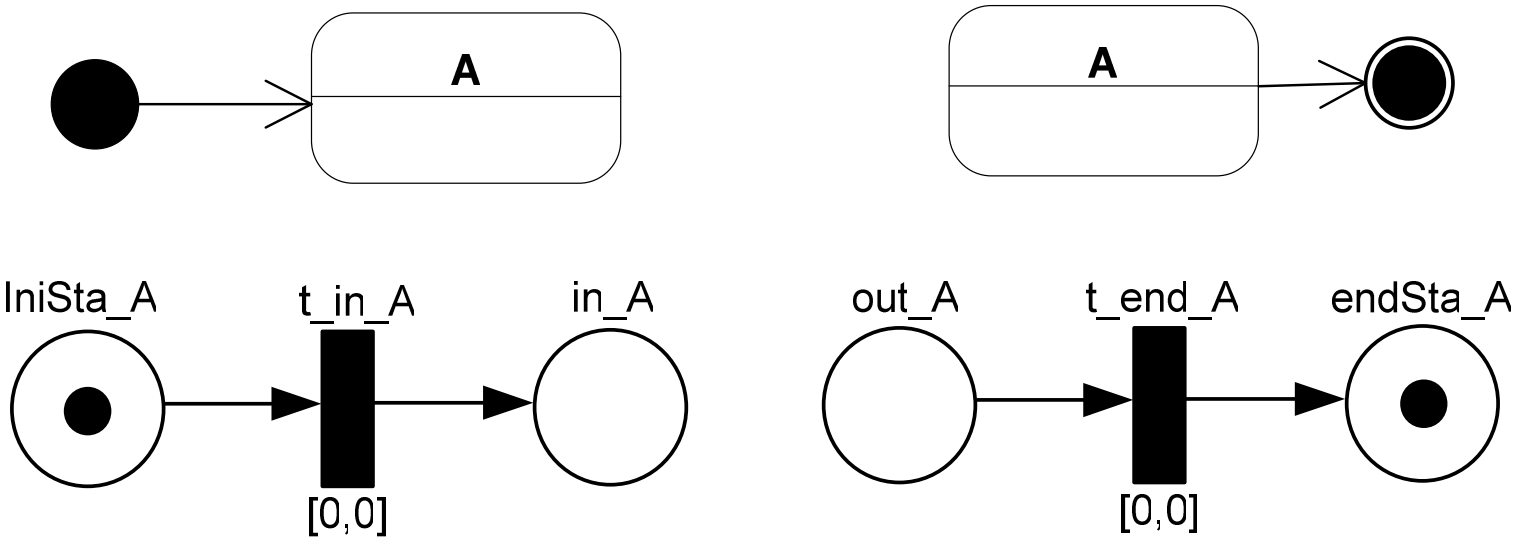
Mapping transitions

Translation

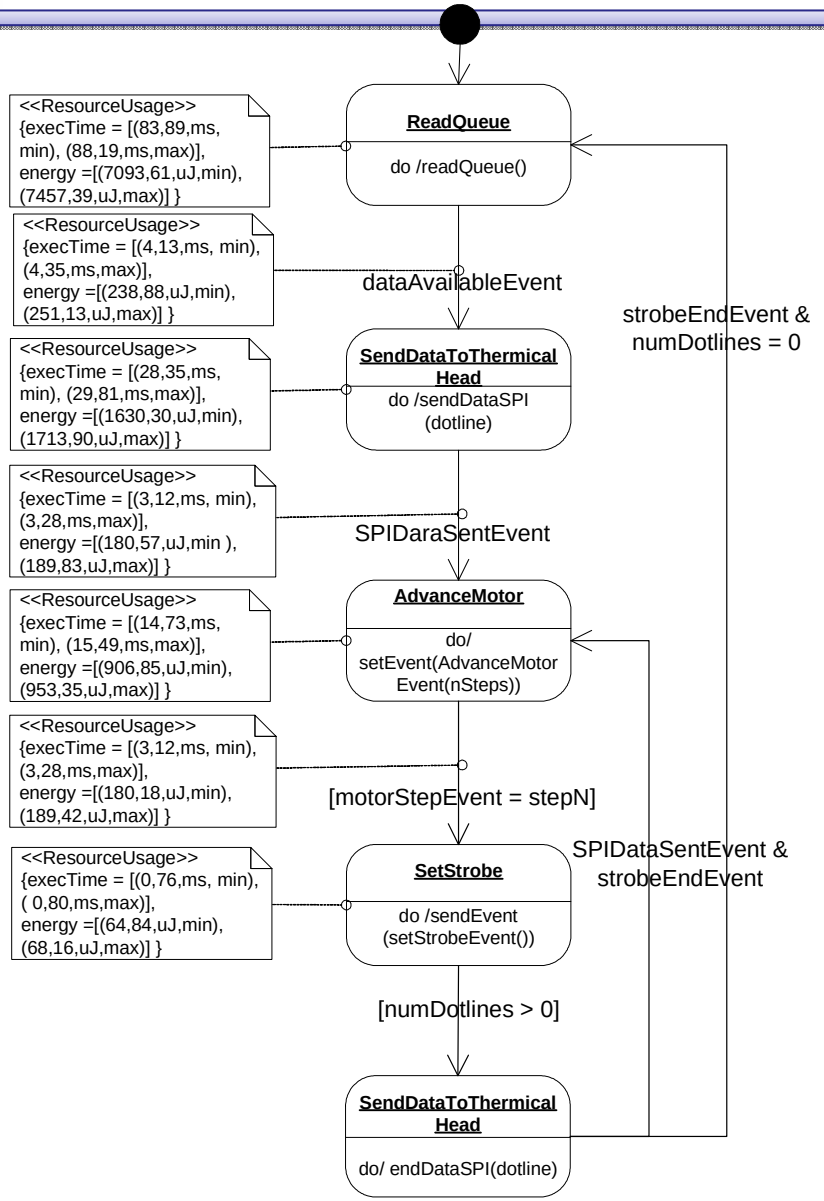


Mapping Initial and Final State

Case Study

- Thermal printer
  - This printer produces a printed image; heating selectively the paper by means of a thermal printing head controlled by a microprocessor.
  - A thermal printer consists of various components.
  - This case study considers the printer controller component, which is the most important one.
  - Such component is responsible of releasing the process that controls the advance motor of the paper as well as the activation of the thermal head.

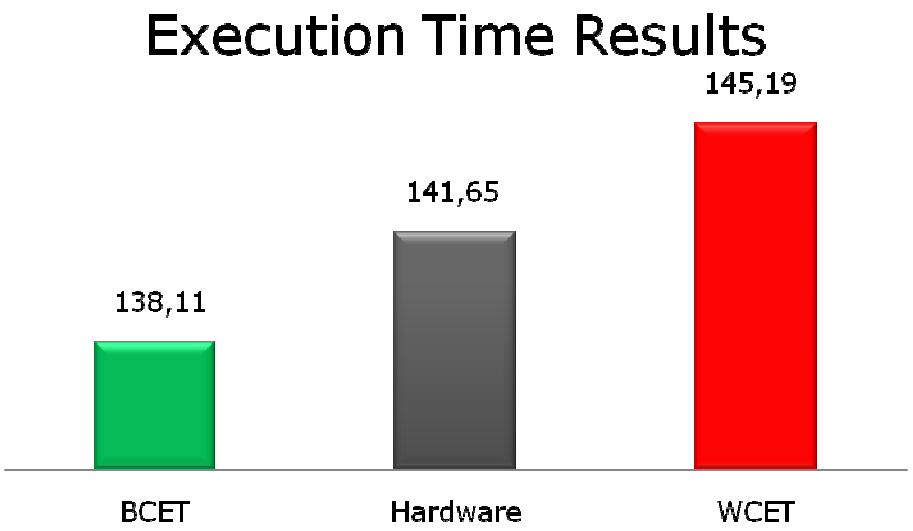
Case Study

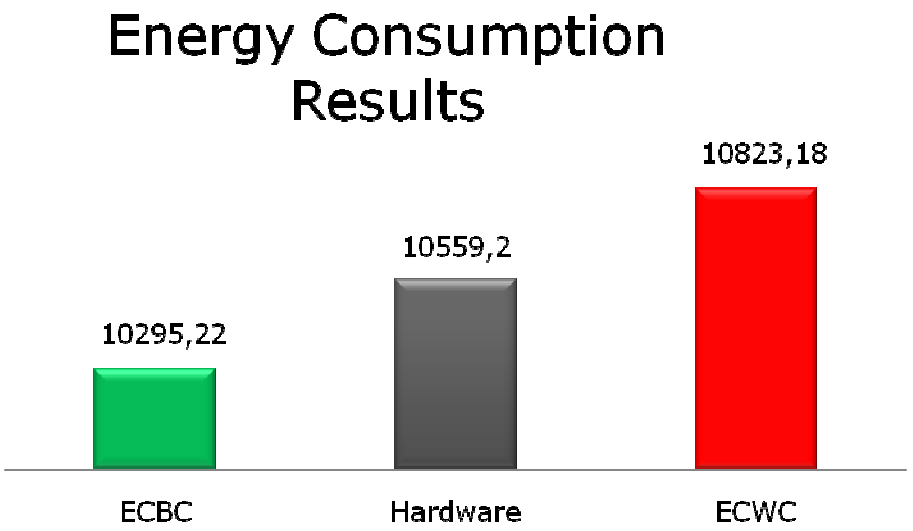


ETPN model of the printer controller component DE.

Evaluation

- ***We use the INA Tool to compute the best and worst cases of the ETPN model for execution time and the respective energy consumption.***





The Error Obtained from the model was smaller than 5% in relation to the measurements conducted on hardware platform.

Evaluation

- Verifications
  - *Deadlock Free* - The component does not have any dead state.
  - Reversibility - The component is not reversible to its initial state, but there are *home states.*

Conclusion

- This research provides
  - Formal approach for mapping State machine diagram into an ETPN;
  - Estimates
    - Energy Consumption;
    - Execution Time.
  - Verifications
- A case study have been conducted.

Future Works

- Develop a tool for automatic generation of ETPNs from SM with MARTE annotation;
- Present the formalism behind this mapping process;
- Carry out other case studies.
  - Wider context, in which interconnected components are considered.

Obrigado!