FROM RESEARCH TO INDUSTRY

A survey of main dataflow MoCCs for CPS design and verification

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Your speaker

- Guillaume Roumage
- 2^{nd} year Ph.D. student
- Ph.D. thesis on the dynamic reconfiguration of CPS while preserving temporal properties
- Selma Azaiez and Stéphane Louise (both co-authors) are my advisors
- A□liates at University Paris-Saclay and CEA (French Alternative Energies and Atomic Energy Commission)

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Motivating example: ADAS

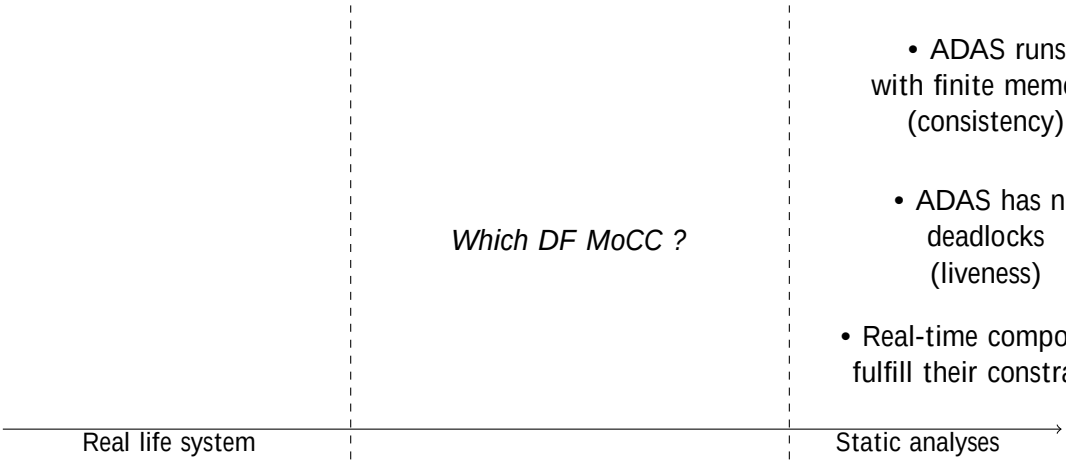
- An autonomous car (ADAS: Advance Driver Assistance System) has several constraints:
  - Real-time constraints (periodic execution of some components)
  - Limited resources (computation, memory)
  - Temporal constraints (latency, throughput)

- How can we ensure ADAS safety without compromising the above constraints?
  (1) Model ADAS (or any CPS) with a Model of Computation and Communication
  (2) Static analysis of the CPS
  (1) + (2) = **MoCC-based design of CPS**

Motivating example: ADAS

- ADAS runs with finite memory (consistency)
- ADAS has no deadlocks (liveness)
- Real-time components fulfill their constraints

Motivating example: ADAS



What are the differences between dataflow MoCCs? How to choose a dataflow MoCC?

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Classi cation of data ow MoCCs I

- Synchronous Data ow and its extension : 10 DF MoCCs
  - SDF semantic ([1]) + another feature, e.g., actors auto-concurrency, multi-dimensional channel, etc.
  - HSDF ([1]), MDSDF ([2]), etc.
- Phase-based data ow MoCCs : 6 DF MoCCs
  - Actors rate's pattern is cyclic
  - CSDF ([3]), FRDF ([4]), etc.
- Data ow MoCCs with timing constraints : 2 DF MoCCs
  - Actors have a frequency and delay constraints
  - TPDF ([5]), PolyGraph ([6])

Classi cation of data ow MoCCs II

- Boolean-based data ow MoCCs : 3 DF MoCCs
  - DF MoCCs that have mechanism(s) triggered by boolean parameters
  - BDF ([7]), IDF ([8]), BPDF ([9])
- Scenario-based data ow MoCCs : 4 DF MoCCs
  - DF MoCCs that have scenarios, i.e., actors' rates and/or execution time may vary
  - SADF ([10]), (P)FSM-SADF ([11], [12]), etc.
- Data ow MoCC with Enable/Invoke capabilities : 5 DF MoCCs
  - DF MoCCs that endow actor with enable capability (i.e., asserts if an actor can re) and invoke capability (i.e., performs a re in that mode)
  - EIDF/CFDF ([13]), HCFDF ([14]), PSM-CFDF ([15])

Classi cation of data ow MoCCs III

- Data ow MoCC with unique features : 3 DF MoCCs
  - SPBDF ([16]): global state
  - HDF ([17]): combination of Finite State Machine and SDF
  - VRDF ([18]): parametric DF with many structural constraints
- Process network-based data ow MoCCs : 2 DF MoCCs
  - Actors may have a state.
  - KPN ([19]), RPN ([20])
- Meta-model for data ow MoCCs : 6 DF MoCCs
  - Additional rules on the top of a DF MoCC.
  - PSDF/PCSDF ([21]), HPDF ([22]), RDF ([23]), etc.

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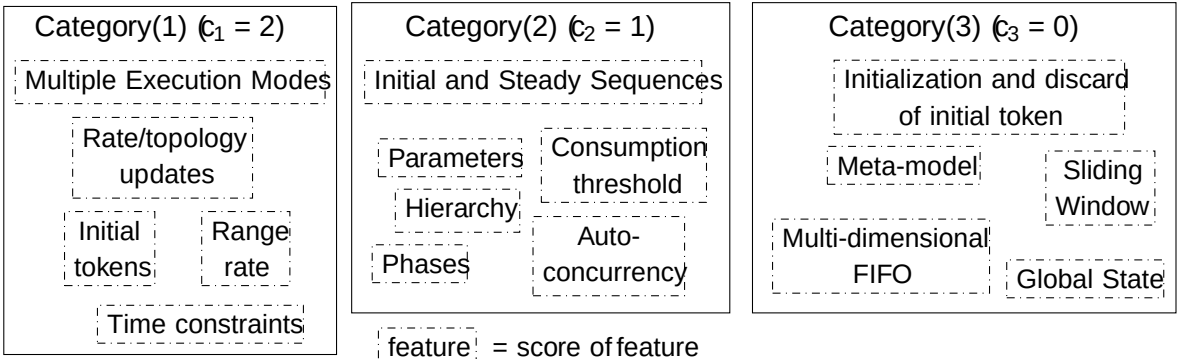
Expressiveness hierarchy: methodology

1. Characterize each DF MoCC according to well-de ned features: rate/topology updates, range rate, parameters, etc.
2. Assign a score to feature and normalize it.
3. Assign a coe cient to each features' score.
4. Compute the expressiveness score by summing the normalized features' score witl its coe cient.

Expressiveness hierarchy: application

- Determining the best DF MoCC to model time-constrained and recon gurable CPS
- We classify feature from the best to the least important.



feature = score of feature

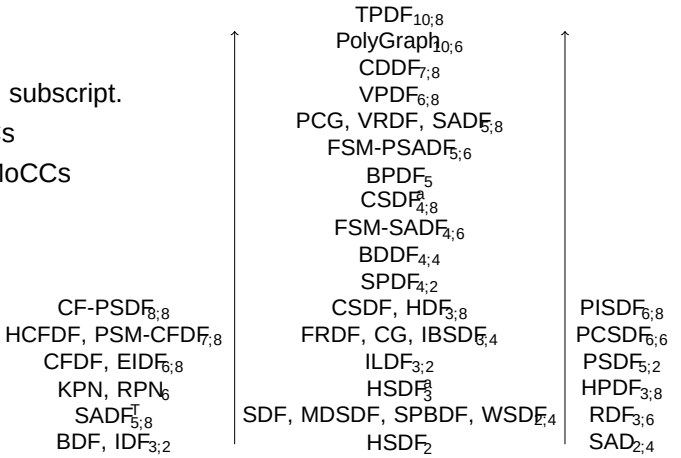
- $\frac{\text{score}}{\max(\text{score})}$ c_i = expressiveness score

$\sum_{i \in \{1;2;3\}} \text{score}_i \cdot \text{category}(i)$

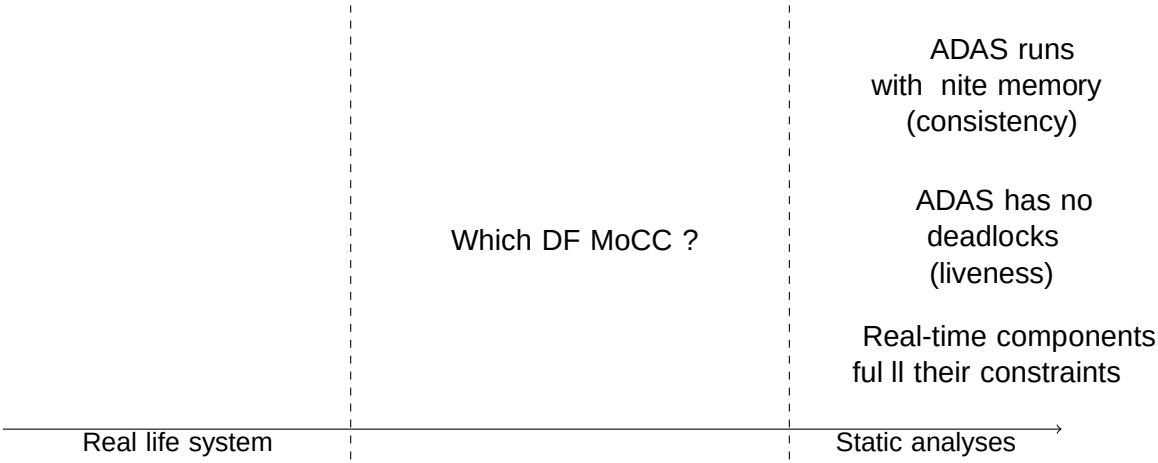
Expressiveness hierarchy: results

- Expressiveness hierarchy of DF MoCCs well-suited to model time-constrained and recon gurable CPS.

- Expressiveness score shown as subscript.
- Left: Turing complete DF MoCCs
- Mid: Non-Turing complete DF MoCCs
- Right: Meta-model DF MoCCs



Back to the ADAS



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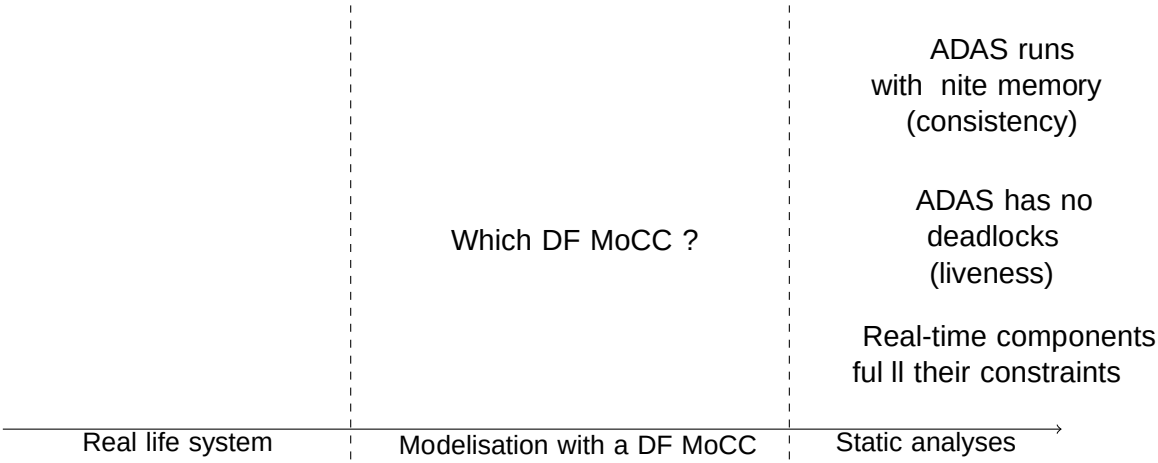

Modelization of the ADAS with the DF MoCC PolyGraph.

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Conclusion

- A short survey on the main DF MoCCs for CPS design and veri cation.
  - Classi cation of DF MoCC in 9 categories.
  - Features and static analyses for a broad set of DF MoCCs.
- A exible expressiveness hierarchy.
  - Help designer's to choose the best DF MoCC for their needs.
  - Easily extensible.
  - Provide a reliable intuition rather than a strict claim.

Conclusion

- A short survey on the main DF MoCCs for CPS design and veri cation.
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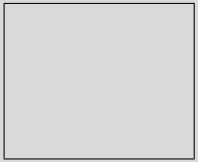
Thank you for your attention. Feel free to ask any questions!



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