Towards adaptive multi-Alternative Process Network

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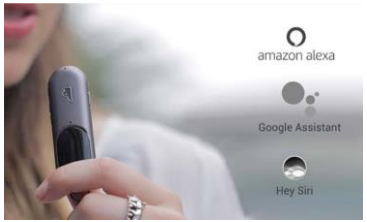
PARMA-DITAM'21 Workshop (co-located with the HiPEAC Conference)

Introduction

Autonomous driving

5G

Medical systems



Biometric authentications
Voice controlled systems
Live streaming subtitling

Introduction

Multiple algorithms

Early and detailed analysis to navigate such complex design space (MoC)

→ Reliable applications

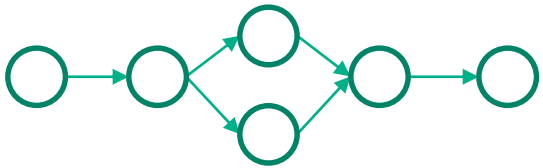
→ Targeted performance

Different constraints:

- Hardware resources
- Energy budget
- User constraints

Introduction

- Model of Computations (MoCs)
  - Fulfill the need for analyzing such complex applications
  - Provide high level presentation and allow for parallelism adaptivity



Applications are getting more complex (parallelism and algorithmic adaptivity) → How to quickly explore large design spaces (taking into account constraints)

Related work

	Adaptivity and contributions
SDF [7,14,22]	Parallelism adaptivity depending on the changes of the target hardware Transformations that adapt the parallelism in SDF according to available resources
SADF [21]	Parallelism adaptivity and pre-defined number of scenarios
PiSDF [3]	Adaptivity is expressed at the token production and consumption level
KPN [16]	Parallelism adaptivity by duplicating stateless processes

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PiSDF [3]	Adaptivity is expressed at the token production and consumption level
KPN [16]	Parallelism adaptivity by duplicating stateless processes
mAPN	Parallelism and algorithmic adaptivity for a large design space

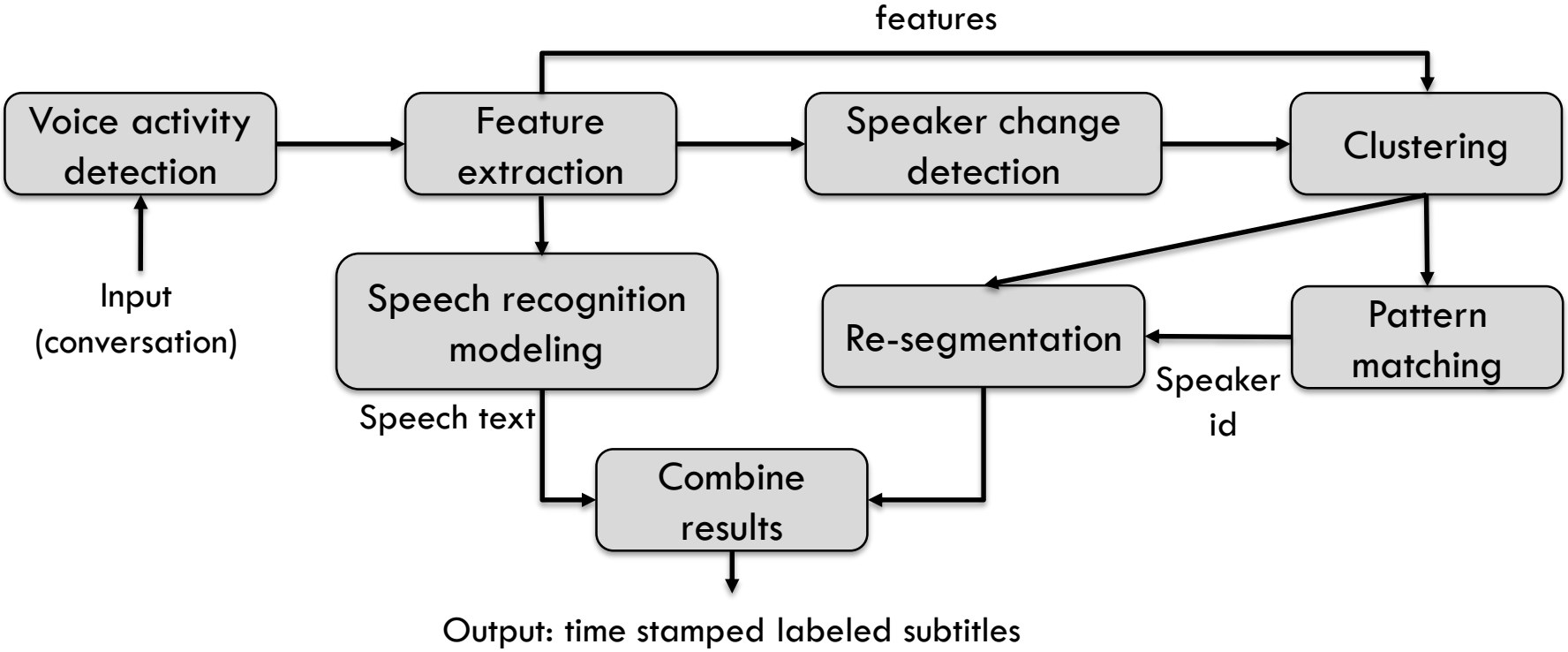
Outline

- Motivational example
- mAPN
  - Synthetic example
  - Exploration algorithm
- Experimental results
  - ASA alternatives
  - Experimental results and fidelity analysis
- Summary and outlook

Motivational example: ASA

- Automatic subtitling application is combined of 3 functionalities:
  - Speaker recognition (who is speaking)
  - Speech recognition (what are they saying)
  - Speaker diarization (when are they speaking)

Automatic subtitling application



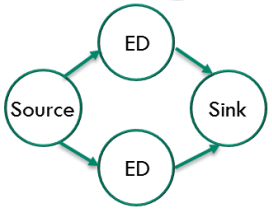
Automatic subtitling application

- Automatic subtitling
  - Feature extraction
    - Mel Frequency Cepstral Coefficients (MFCC)

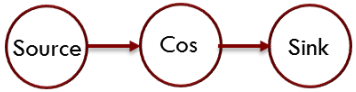
    - Fourier Bessel Cepstral Coefficients (FBCC)

  - Pattern Matching
    - Euclidean Distance (DE) compact

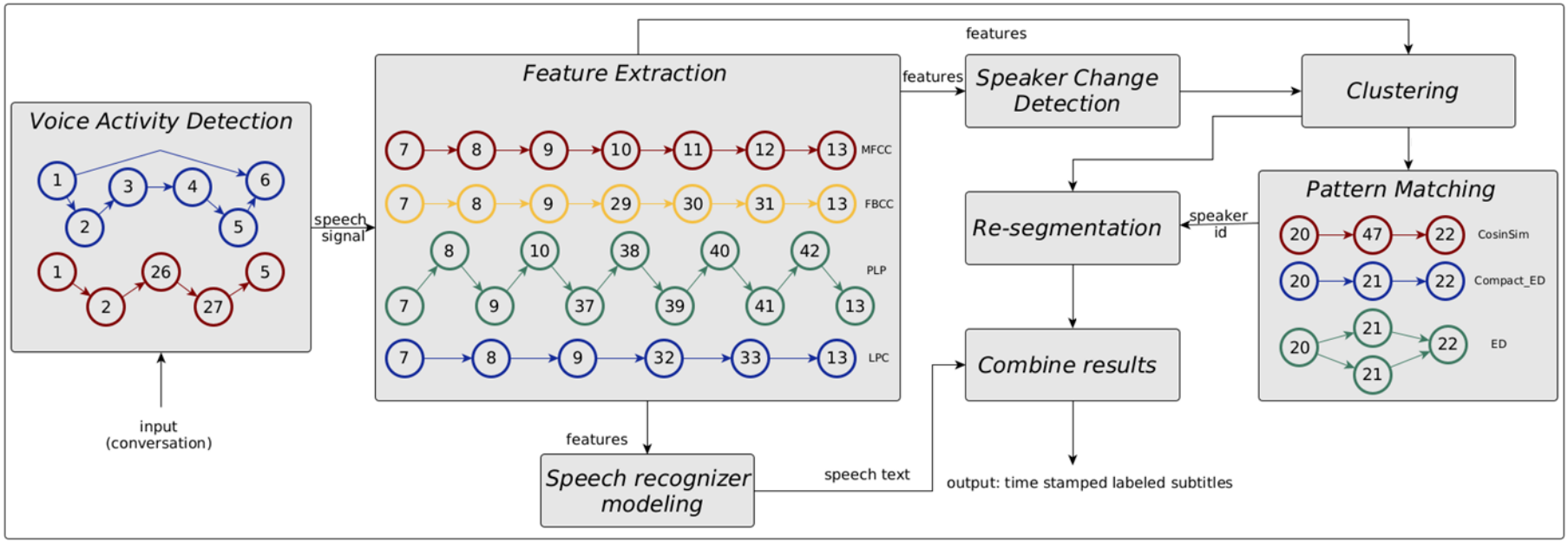
    - Euclidean distance expanded



    - Cosine Similarity



Automatic subtitling application



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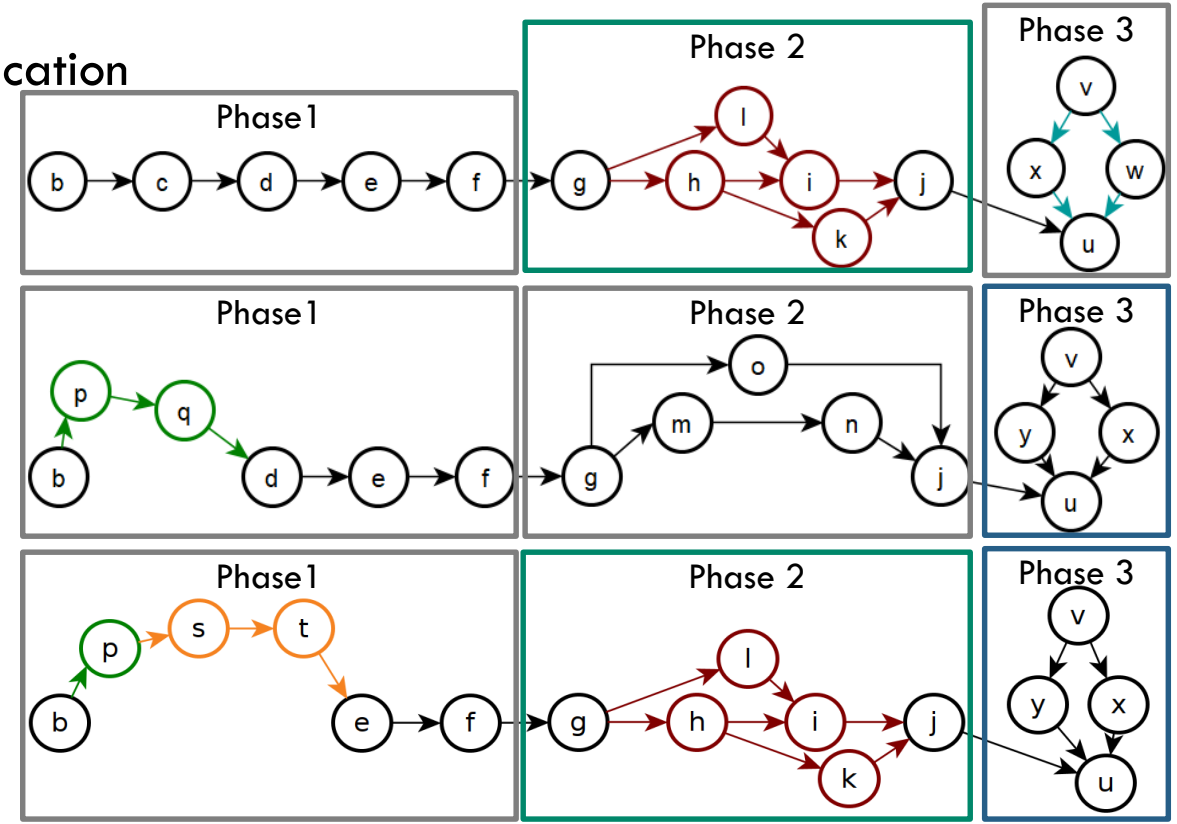
mAPN: synthetic example

- If we consider an application
  - Implementation 1
  - Implementation 2
  - Implementation 3



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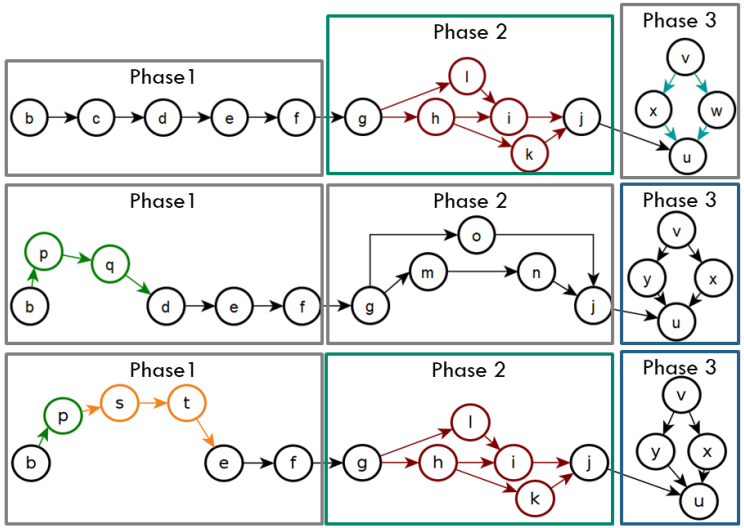
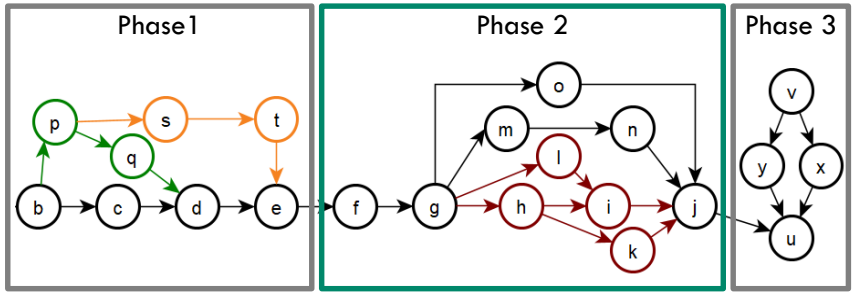
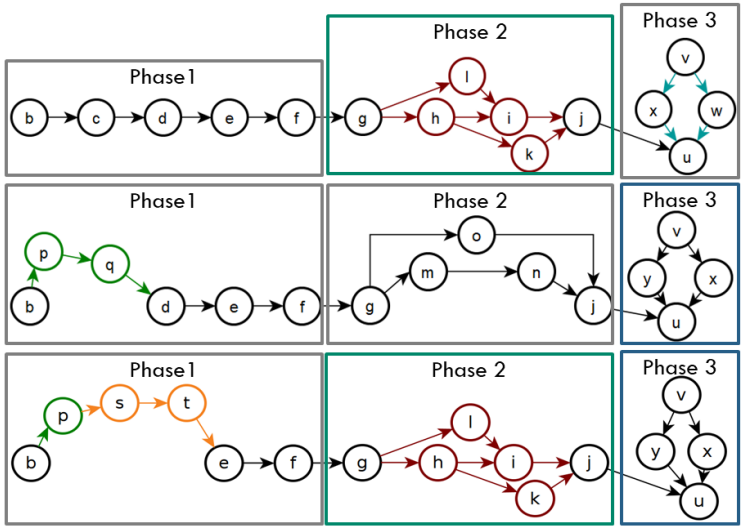


Application with N implementations



Compact Graph (mAPN)

mAPN: synthetic example



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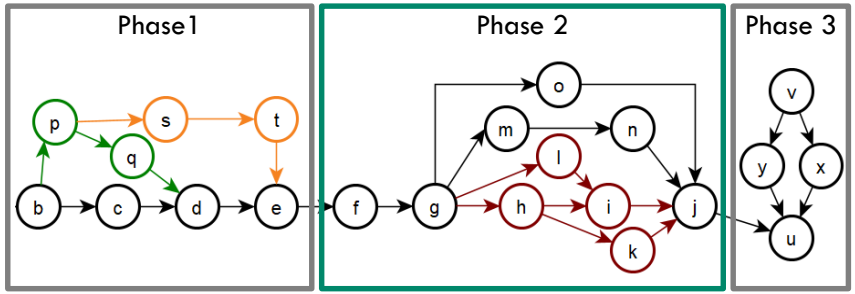
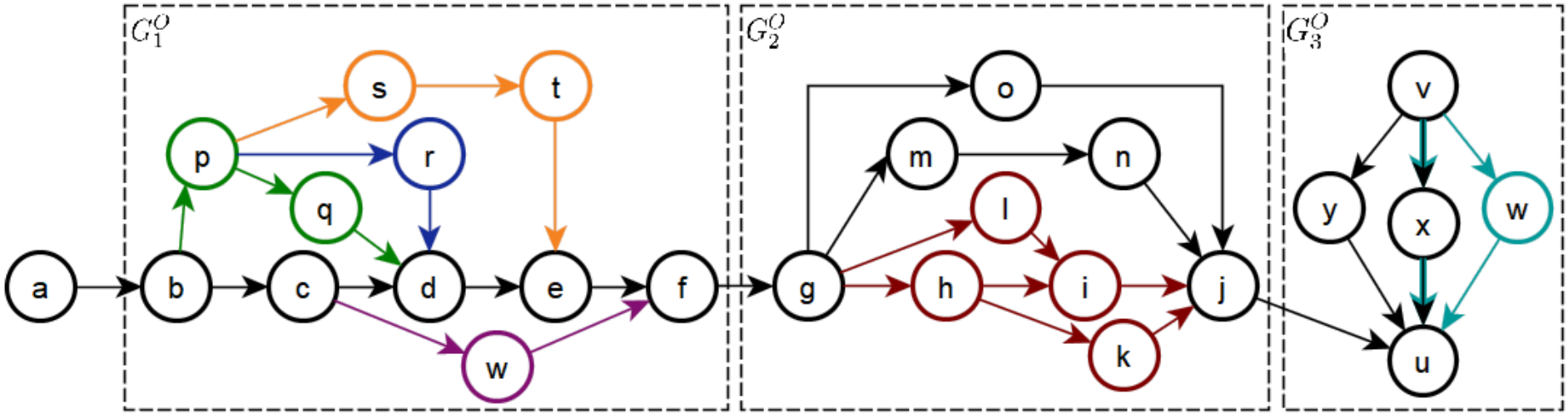


Compact Graph (mAPN)

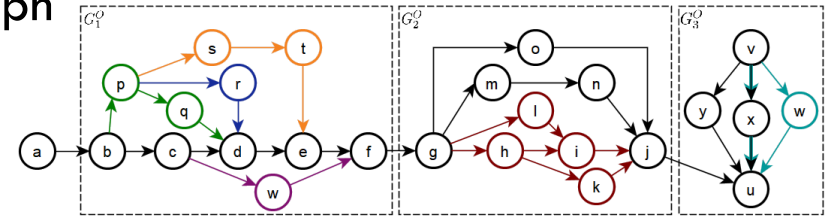
How can we explore the graph to extract the different implementations?

mAPN: synthetic example

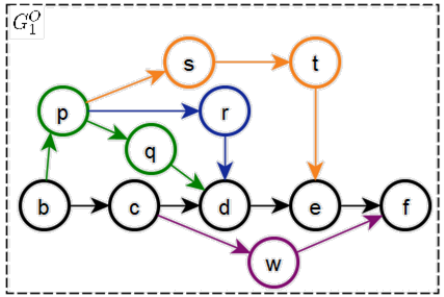


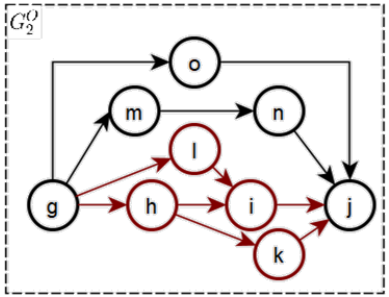
mAPN: Exploration algorithm

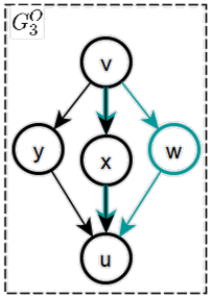
- Generic example of multi-alternative graph



  - Define the ClosedGraphs ()
    - Well formed graph
    - No loop back
    - Minimal cannot include more than one closed sub-mAPN
    - The set of colors that fork within a closed subgraph is the same that joins
  - Remove common nodes

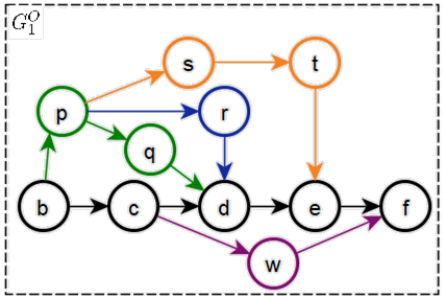


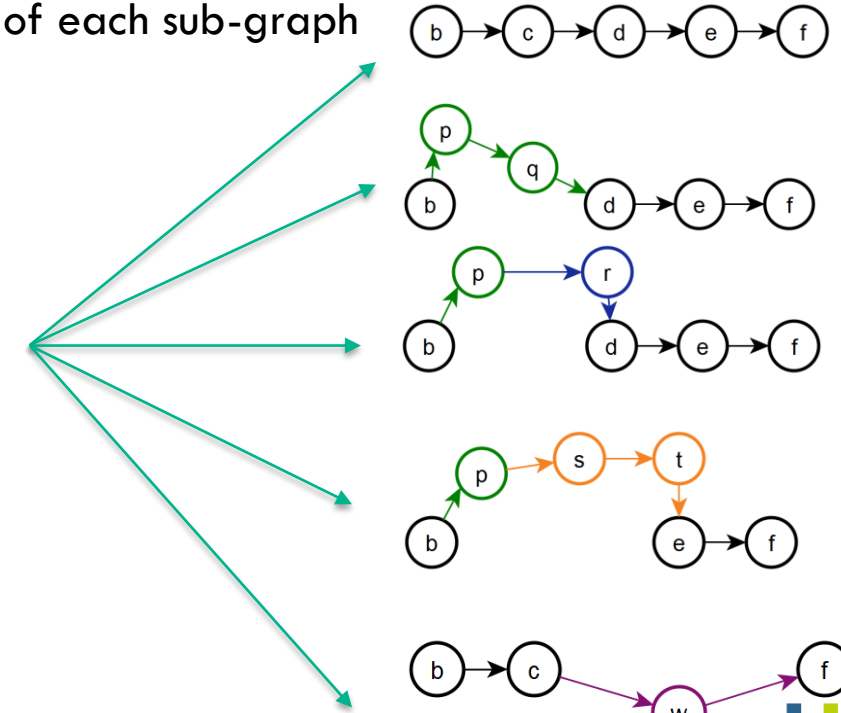




mAPN: Exploration algorithm

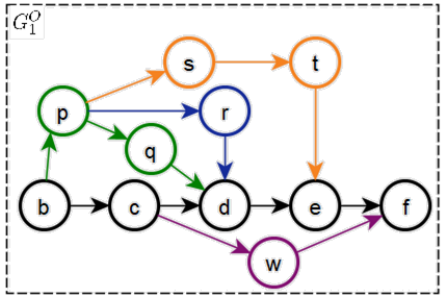
- Generic example of multi-alternative graph
  - Generate possible alternatives of each sub-graph

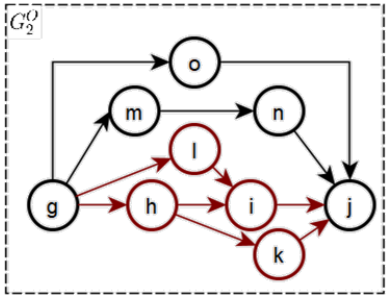


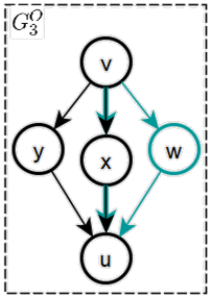


mAPN: Exploration algorithm

- Generic example of multi-alternative graph
  - Mix and match possible alternatives of sub-graphs



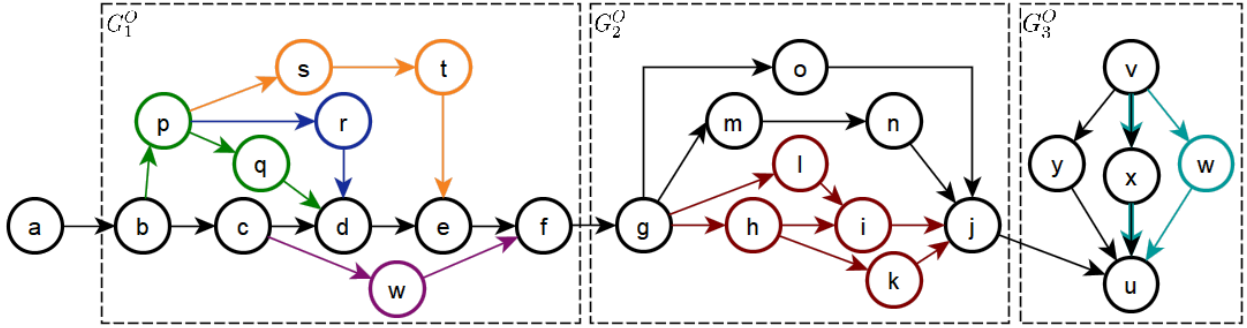




5 × 2 × 2 = 20 Alts

mAPN: Exploration algorithm

- Generic example of multi-alternative graph



mAPN: Exploration algorithm

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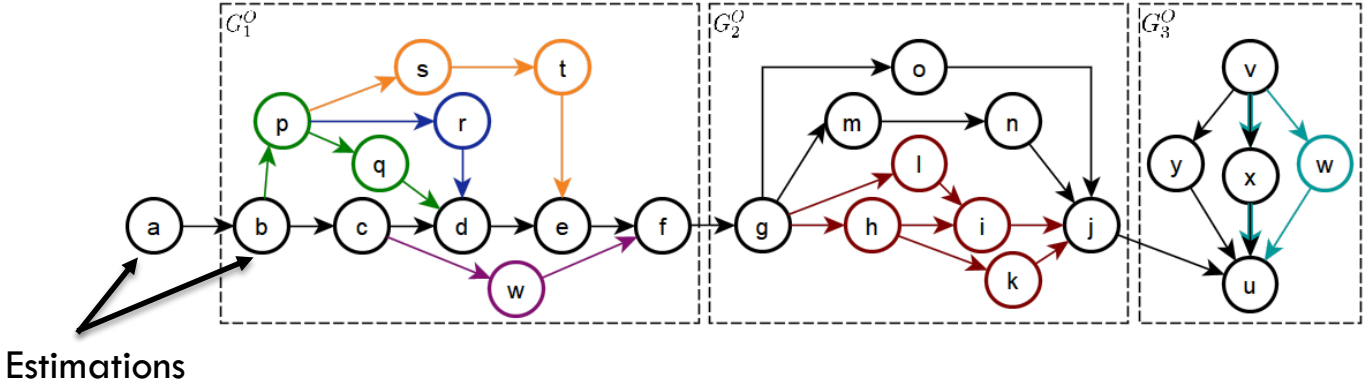

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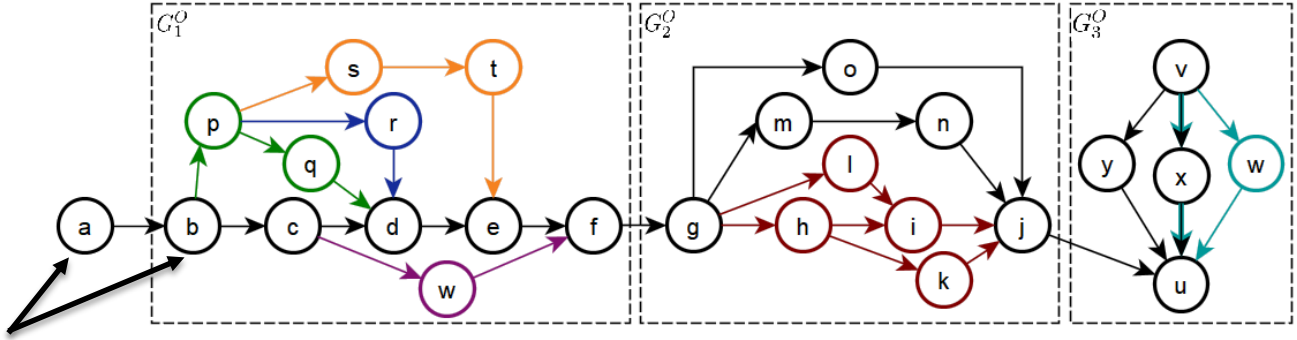
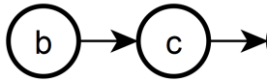
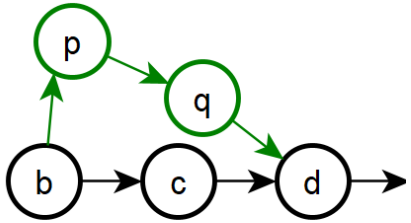


Estimations

Evaluation (Max-Plus algebra)



T = Tb +Tc



T = max (Tbcd +Tbqp)

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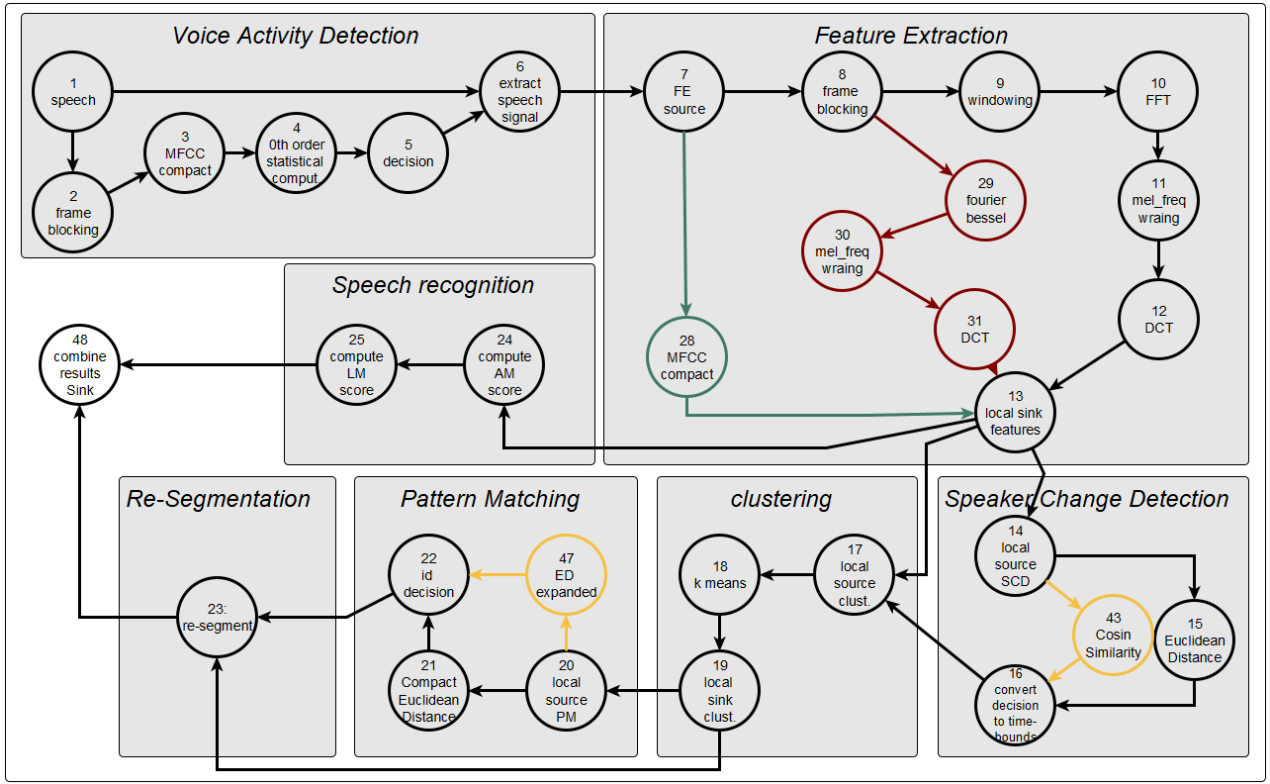
Experimental results



Experimental results

	Estimations				Real Exp. Results			
	Odroid		GPP		Odroid	R/F	GPP	R/F
Alt 1: {VAD-FE(Bessel)-SCD(ED)-Cl-PM(DLP-4)}	102.36	✗	26.24	✓	56.43	R	20.66	R
Alt 2: {VAD-FE(Exp.MFCC)-SCD(ED)-Cl-PM(DLP-4)}	52.11	✓	11.53	✓	24.43	R	9.94	R
Alt 3: {VAD-FE(Comp.MFCC)-SCD(ED)-Cl-PM(DLP-4)}	51.80	✓	10.56	✓	23.66	R	9.66	R
Alt 4: {VAD-FE(Bessel)-SCD(ED)-Cl-PM(DLP-1)}	115.20	✗	30.74	✓	67.69	R	25.73	R
Alt 5: {VAD-FE(Exp.MFCC)-SCD(ED)-Cl-PM(DLP-1)}	64.95	✗	16.03	✓	53.78	F	20.54	R
Alt 6: {VAD-FE(Comp.MFCC)-SCD(ED)-Cl-PM(DLP-1)}	64.64	✗	15.06	✓	52.78	F	19.51	R
Alt 7: {VAD-FE(Bessel)-SCD(CS)-Cl-PM(DLP-4)}	102.35	✗	26.23	✓	45.72	F	20.93	R
Alt 8: {VAD-FE(Exp.MFCC)-SCD(CS)-Cl-PM(DLP-4)}	52.10	✓	11.52	✓	23.10	R	10.05	R
Alt 9: {VAD-FE(Comp.MFCC)-SCD(CS)-Cl-PM(DLP-4)}	51.79	✓	10.55	✓	23.68	R	9.32	R
Alt 10: {VAD-FE(Bessel)-SCD(CS)-Cl-PM(DLP-1)}	115.19	✗	30.73	✓	56.88	R	20.42	R
Alt 11: {VAD-FE(Exp.MFCC)-SCD(CS)-Cl-PM(DLP-1)}	64.94	✗	16.02	✓	53.74	F	19.94	R
Alt 12: {VAD-FE(Comp.MFCC)-SCD(CS)-Cl-PM(DLP-1)}	64.63	✗	15.05	✓	55.47	R	20.01	R

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Constraint = 55ms

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Constraint = 55ms 66,66%

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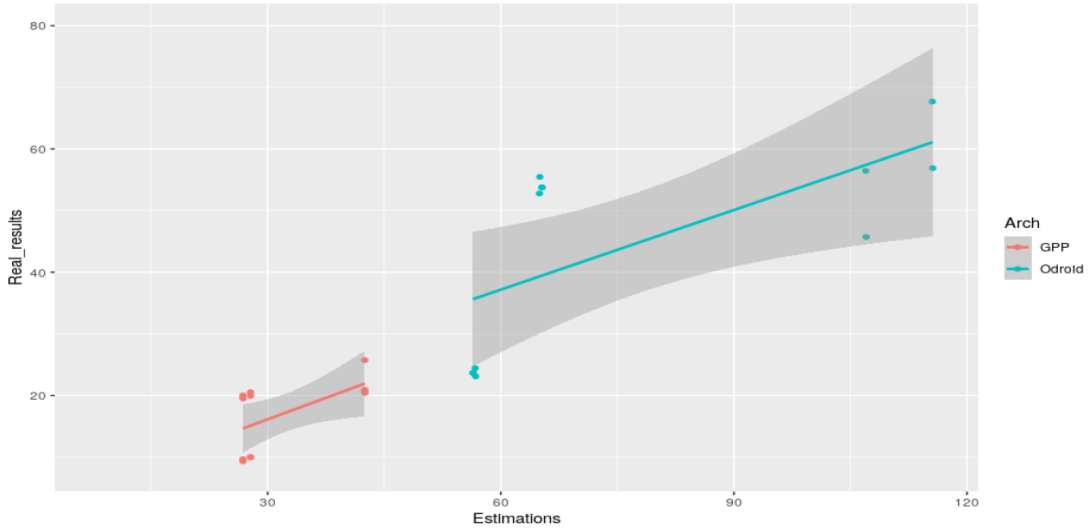
Constraint = 55ms 66,66% 100%

Experimental results



Spearman = 0,936 Kendall = 0,802

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Summary

- mAPN, a novel model where multiple algorithms variants are represented in a compact graph
- mAPN is able to express parallelism and algorithmic adaptivity
- Enlarge the design space and ease the process of selecting feasible variants while meeting application/user constraints
- Approach by the real application: Automatic subtitling

Outlook

- Enlarge the design space and increase the number of possibilities to better study the scalability of our approach
- Investigate on more elaborated aggregation rules and more accurate methods of estimations
- Investigate efficient run-time algorithmic switching mechanisms
- Consider aggregation and evaluation over more abstract domain specific metrics like accuracy

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Thank you for your attention

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