Performance Analysis of Cyclic Dataflow Graphs

Third International Workshop on
Foundations and Applications of Component-based Design

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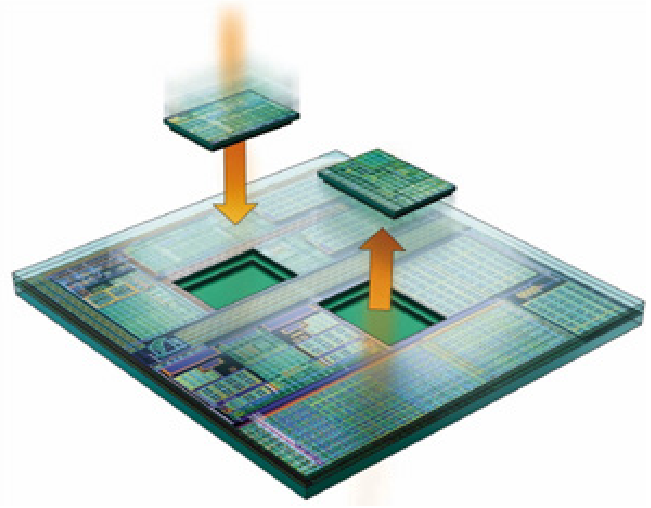
Analysis and Design

Embedded System =

Computation + Communication + Resource Interaction

Analysis:

Infer system properties from subsystem properties.

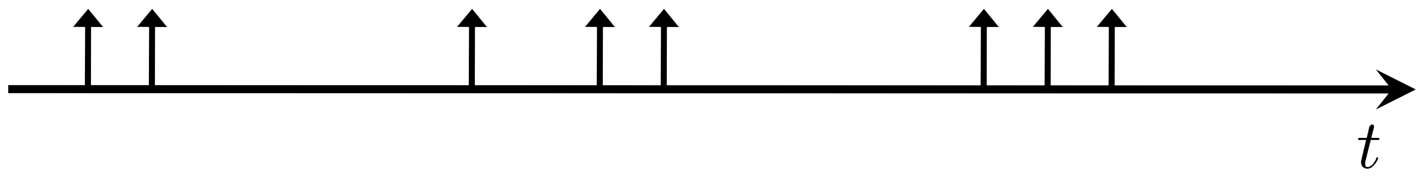


Design:

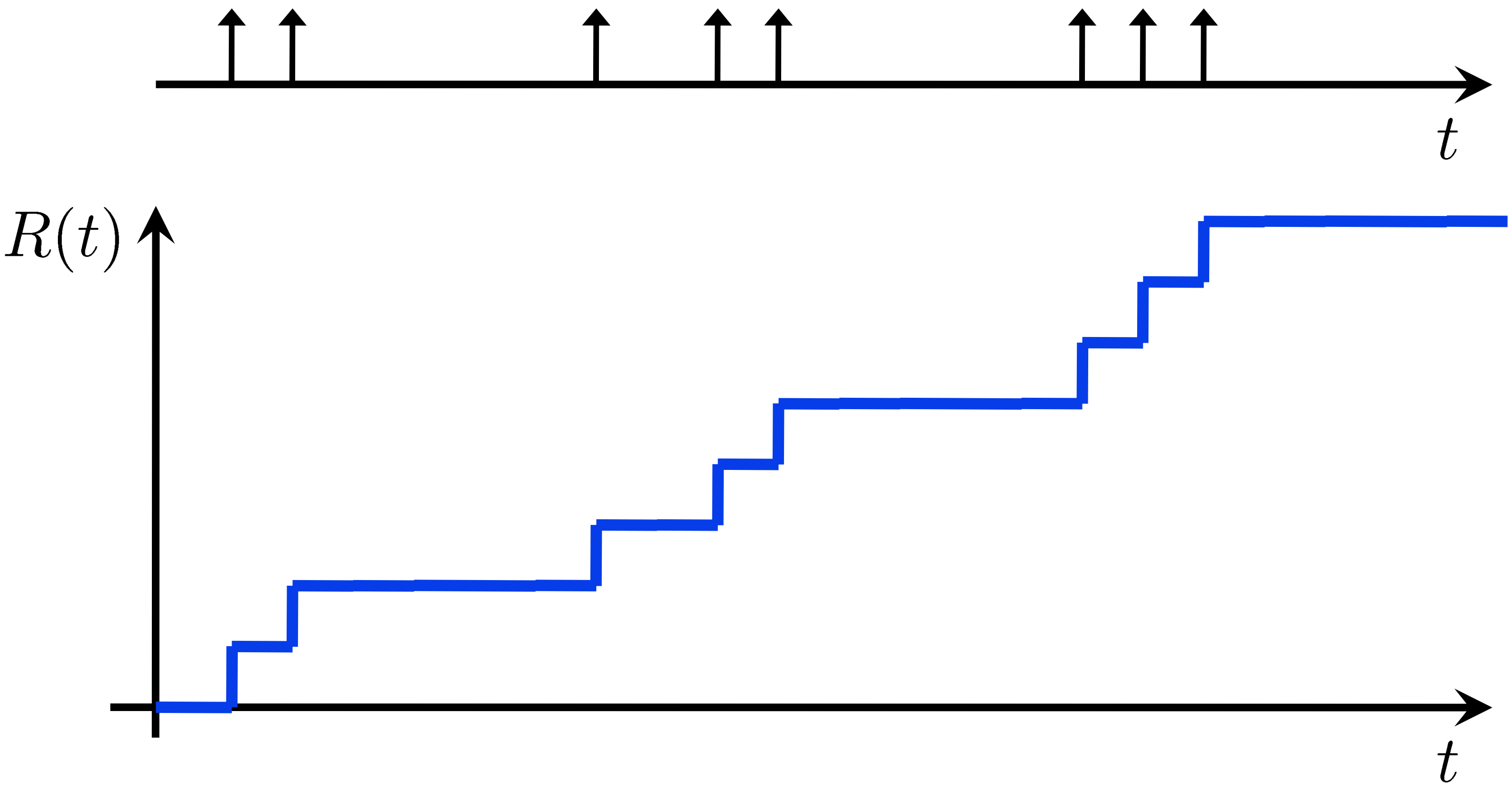
Build a system from subsystems while meeting requirements.

extend the scope of analytic methods

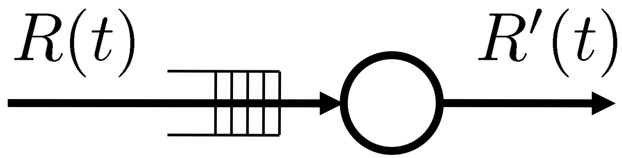
stream



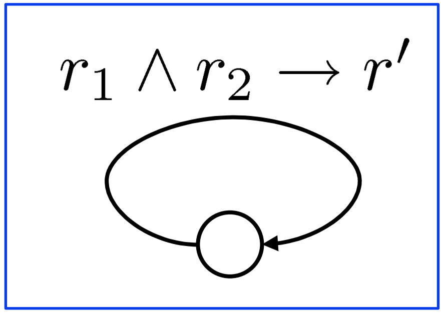
stream

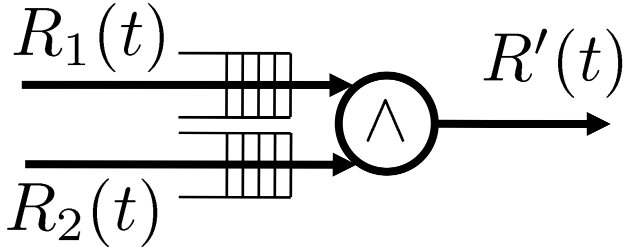


process

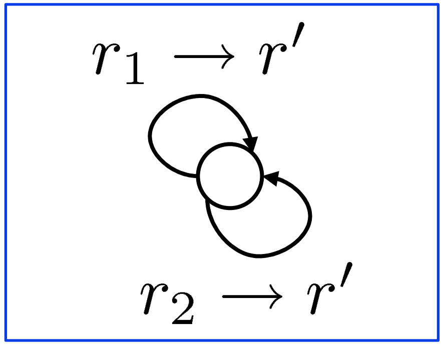


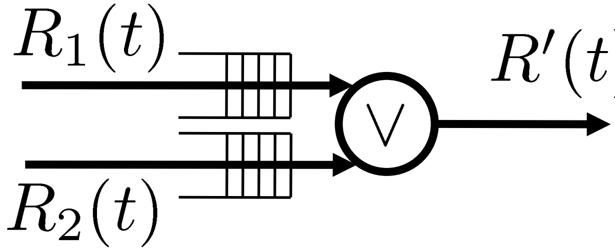
process examples



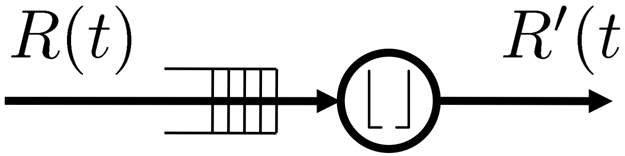


$$R'(t) = \min\{R_1(t), R_2(t)\}$$





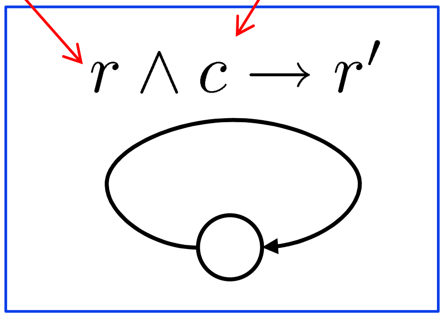
$$R'(t) = R_1(t) + R_2(t)$$

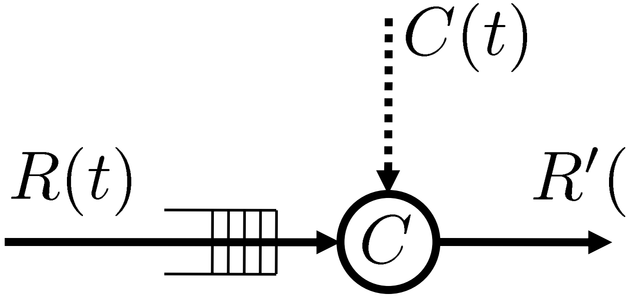


$$R'(t) = \lfloor \sigma \cdot R(t) \rfloor$$

resource interaction

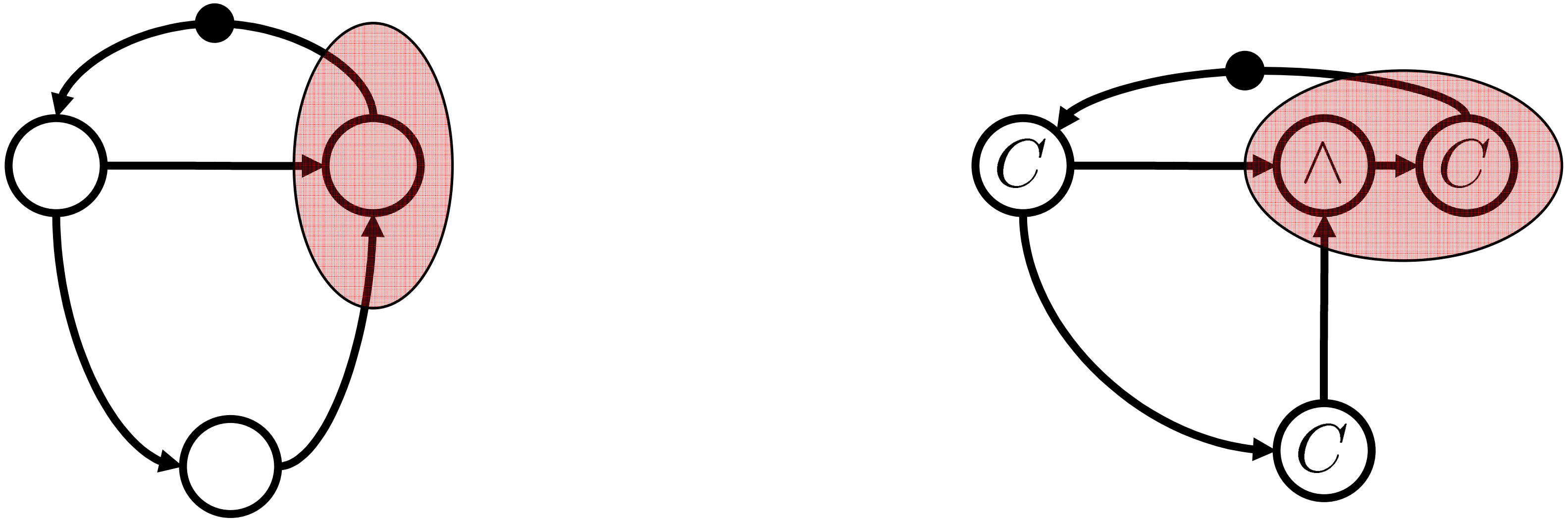
transfer events if resources are available



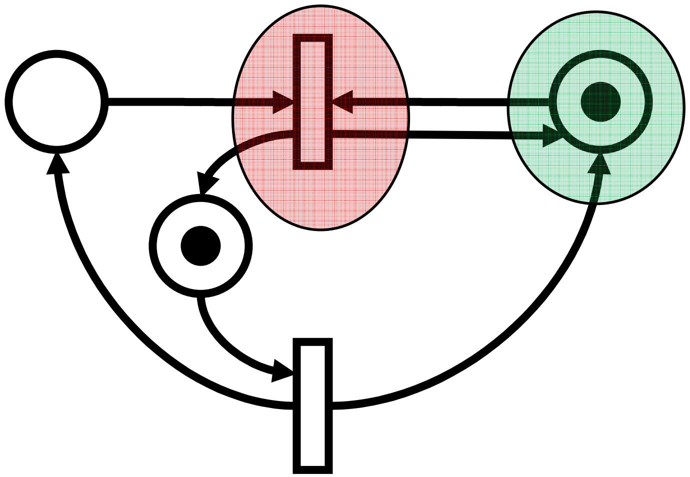


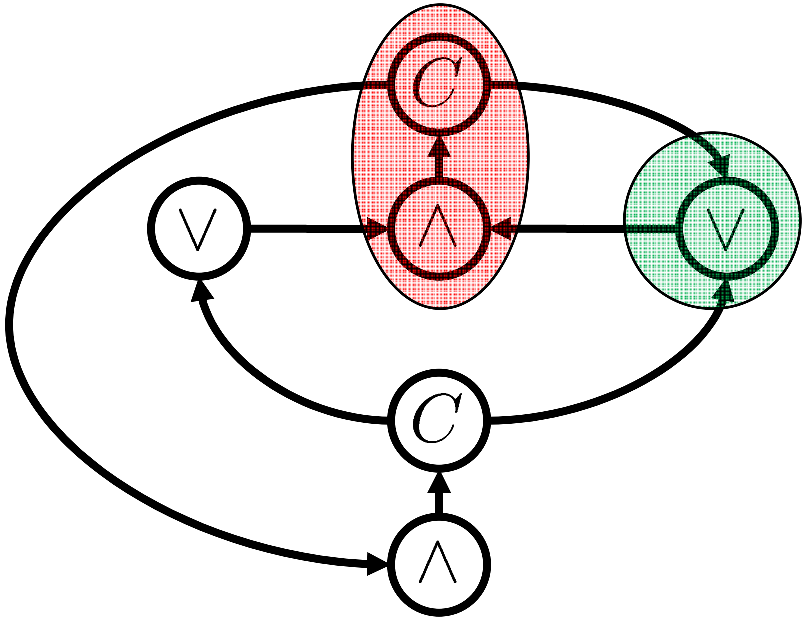
$$R'(t) = \inf_{0 \leq \lambda \leq t}\{R(\lambda) + C(t) - C(\lambda)\}$$

example marked graph

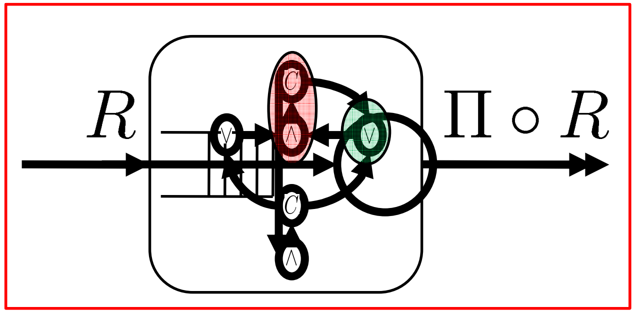


example petri net





properties



monotone components: $R_1 \geq R_2 \longrightarrow \Pi \circ R_1 \geq \Pi \circ R_2$

system simulation: $R_i = \Pi \circ R_{i-1}$

unique fixed point: $R = \Pi \circ R$

abstraction

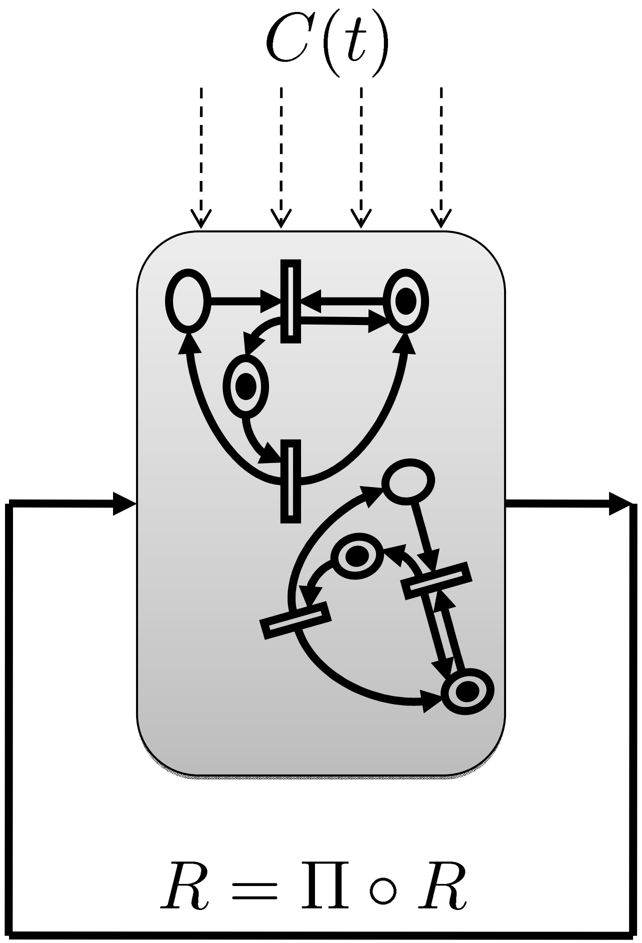
system abstraction: $\Pi^u \geq \Pi \geq \Pi^l$

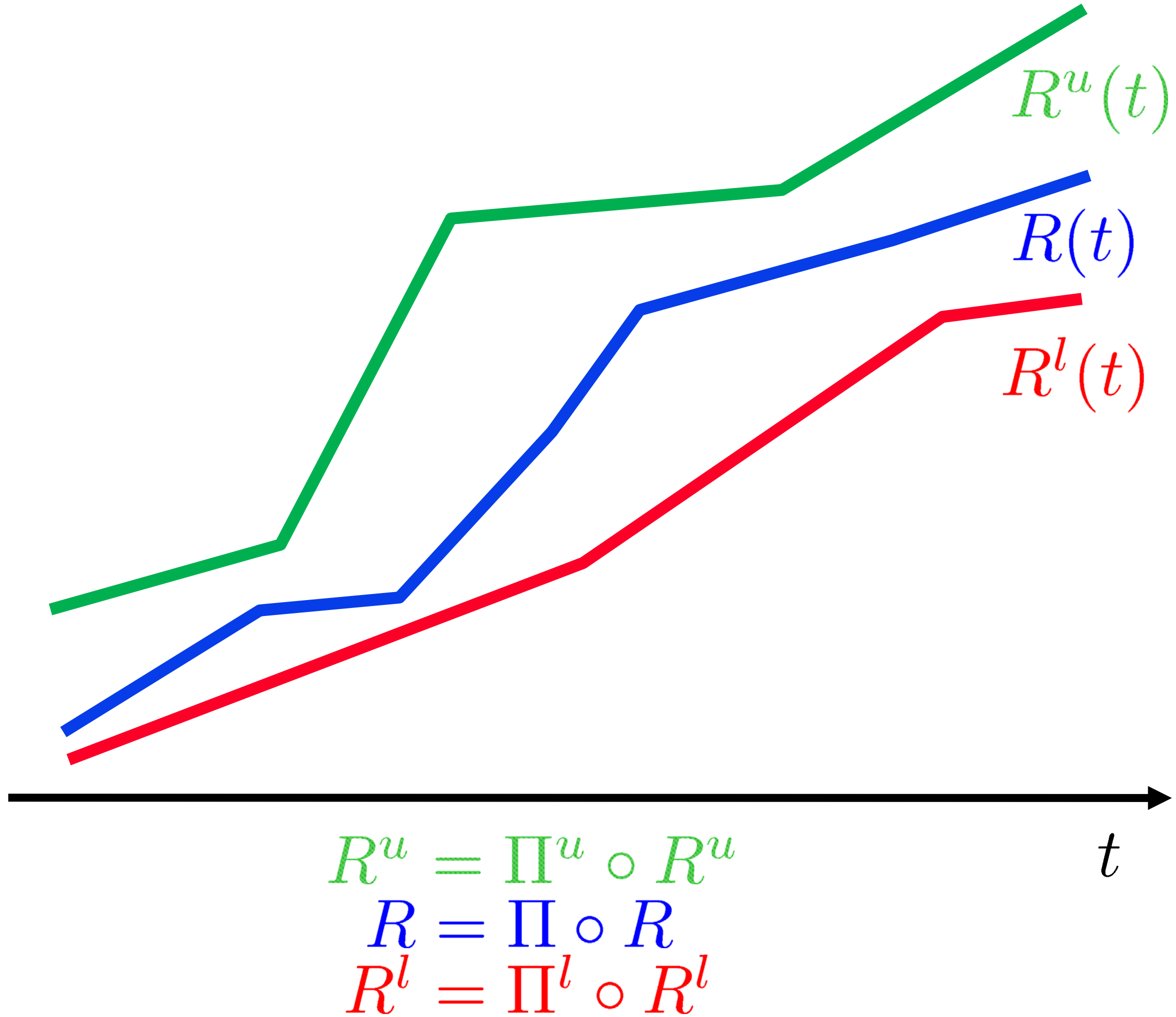
fixpoints: $R^u = \Pi^u \circ R^u \qquad R^l = \Pi^l \circ R^l$

stream bounds: $R^u \geq R \geq R^l$

introduce non-determinism

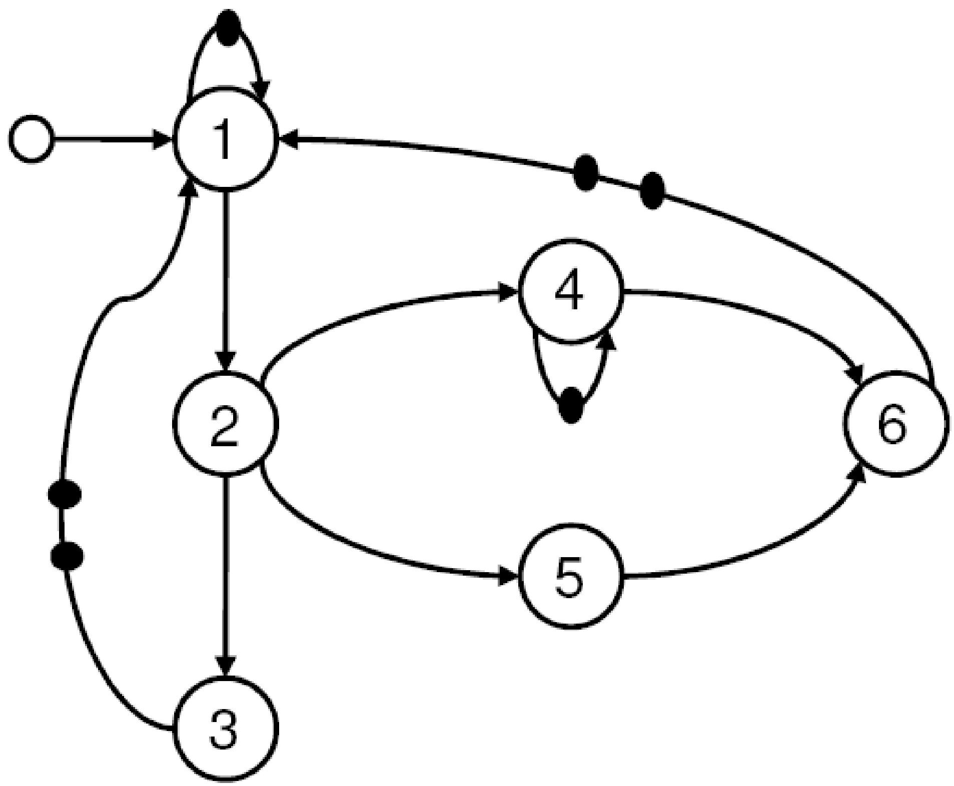
use



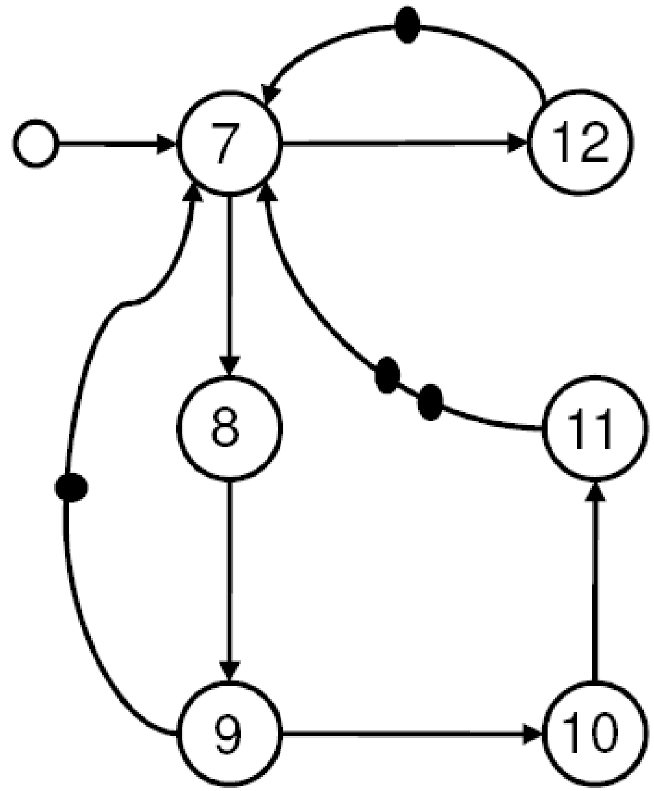


analysis of marked graphs

examples



TD-SCDMA



WLAN

questions

performance analysis of marked graphs has a long history, some results are related to (min,+) algebra

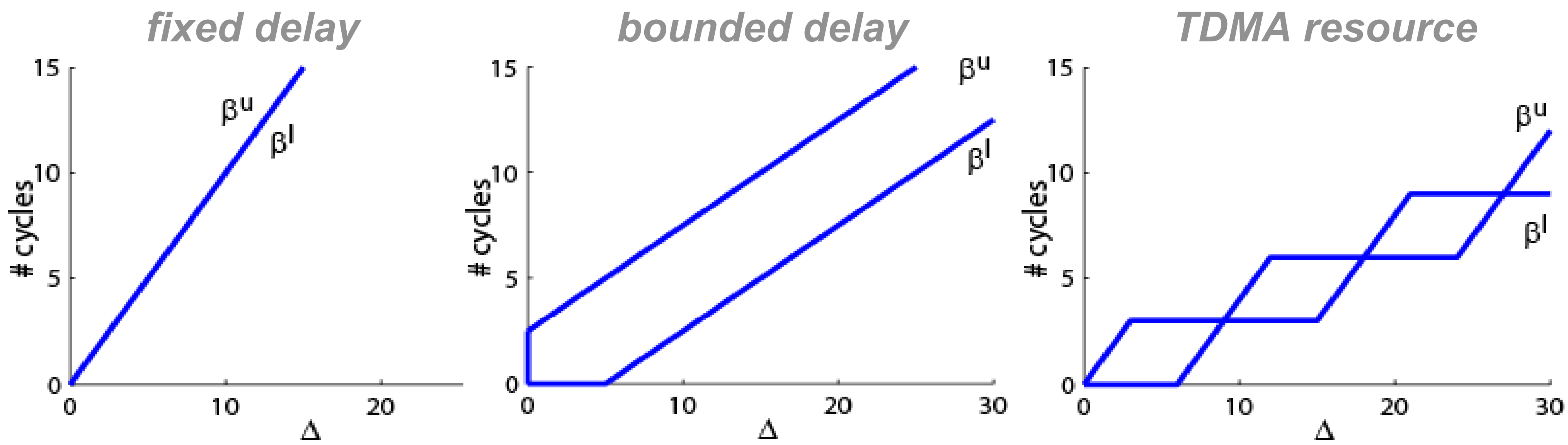
what is the performance in case of complex resource resource sharing (TDMA scheduling, fixed priority)?

how can we analyze properties related to jitter, bursts, non-periodic input streams, end-to-end delays?

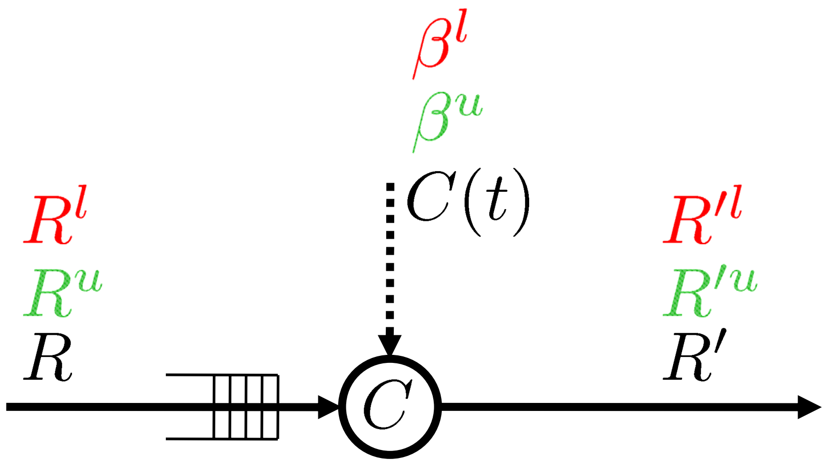
how do appropriate interfaces/components look like?

resource abstraction

$$\beta^l(t-s) \leq C(t) - C(s) \leq \beta^u(t-s)$$



resource abstraction

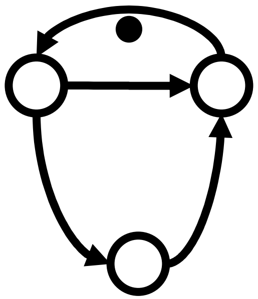


$$R'(t) = \inf_{0 \le \lambda \le t}\{R(\lambda) + C(t) - C(\lambda)\}$$

$$R'^u(t) = \inf_{0 \le \lambda \le t}\{R^u(\lambda) + \beta^u(t - \lambda)\} = R^u \otimes \beta^u$$

$$R'^l(t) = \inf_{0 \le \lambda \le t}\{R^l(\lambda) + \beta^l(t - \lambda)\} = R^l \otimes \beta^l$$

system equations

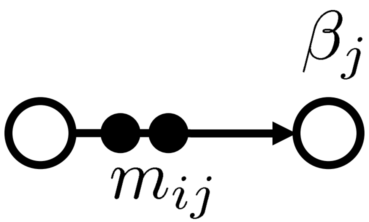


$$R^u = \beta^u \wedge S^u \otimes R^u$$
$$R^l = \beta^l \wedge S^l \otimes R^l$$

smallest upper bound

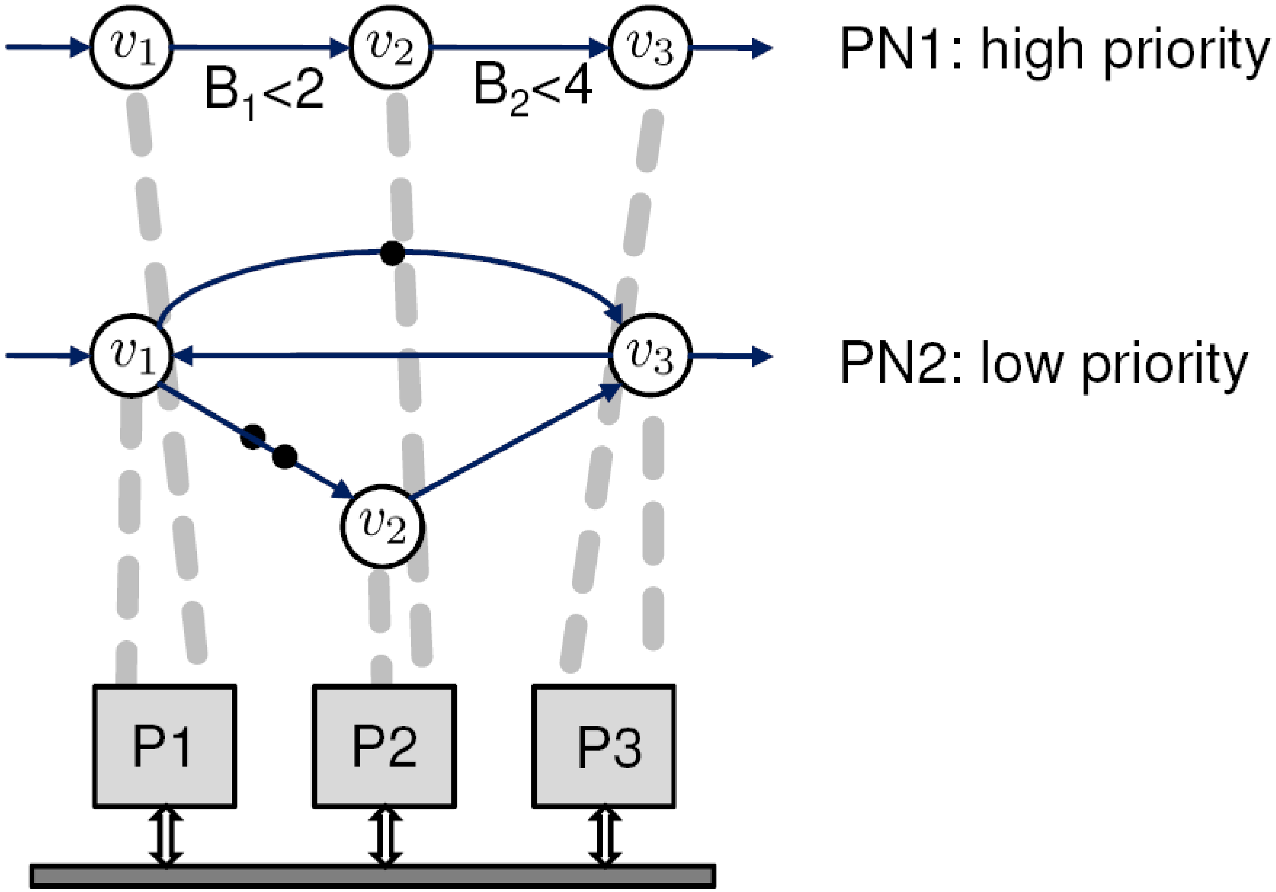
$$R^u = (S^u)^* \otimes \beta^u$$
$$R^l = (S^l)^* \otimes \beta^l$$

largest lower bound

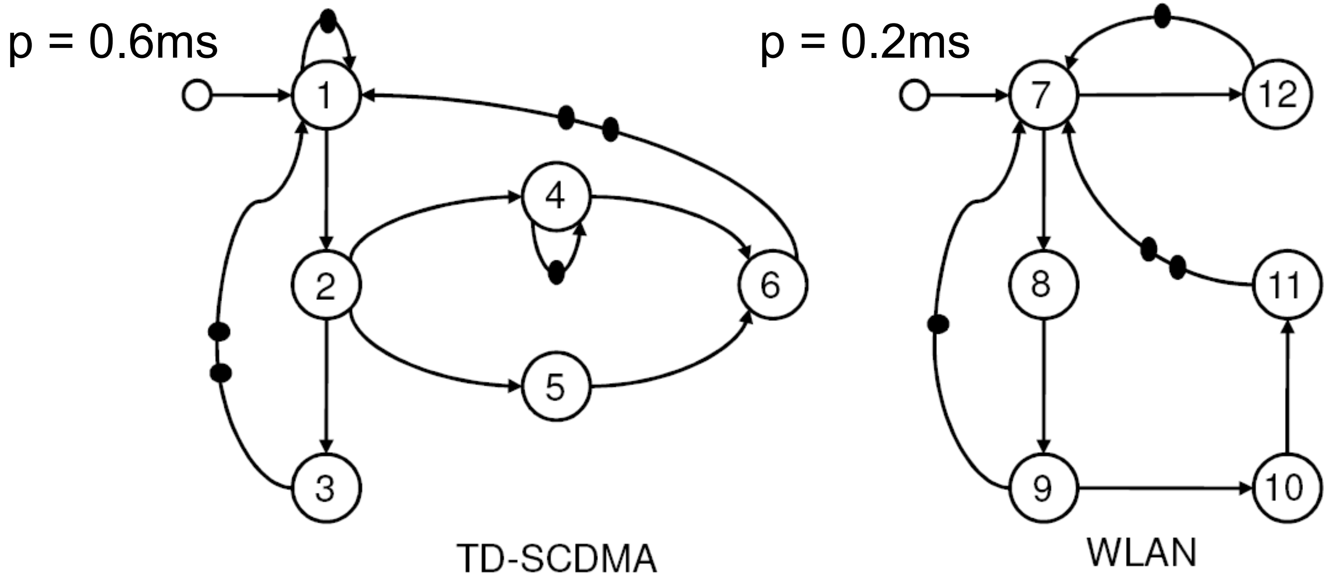


$$S_{ji} = m_{ij} + \beta_j$$

abstract example



SDR example



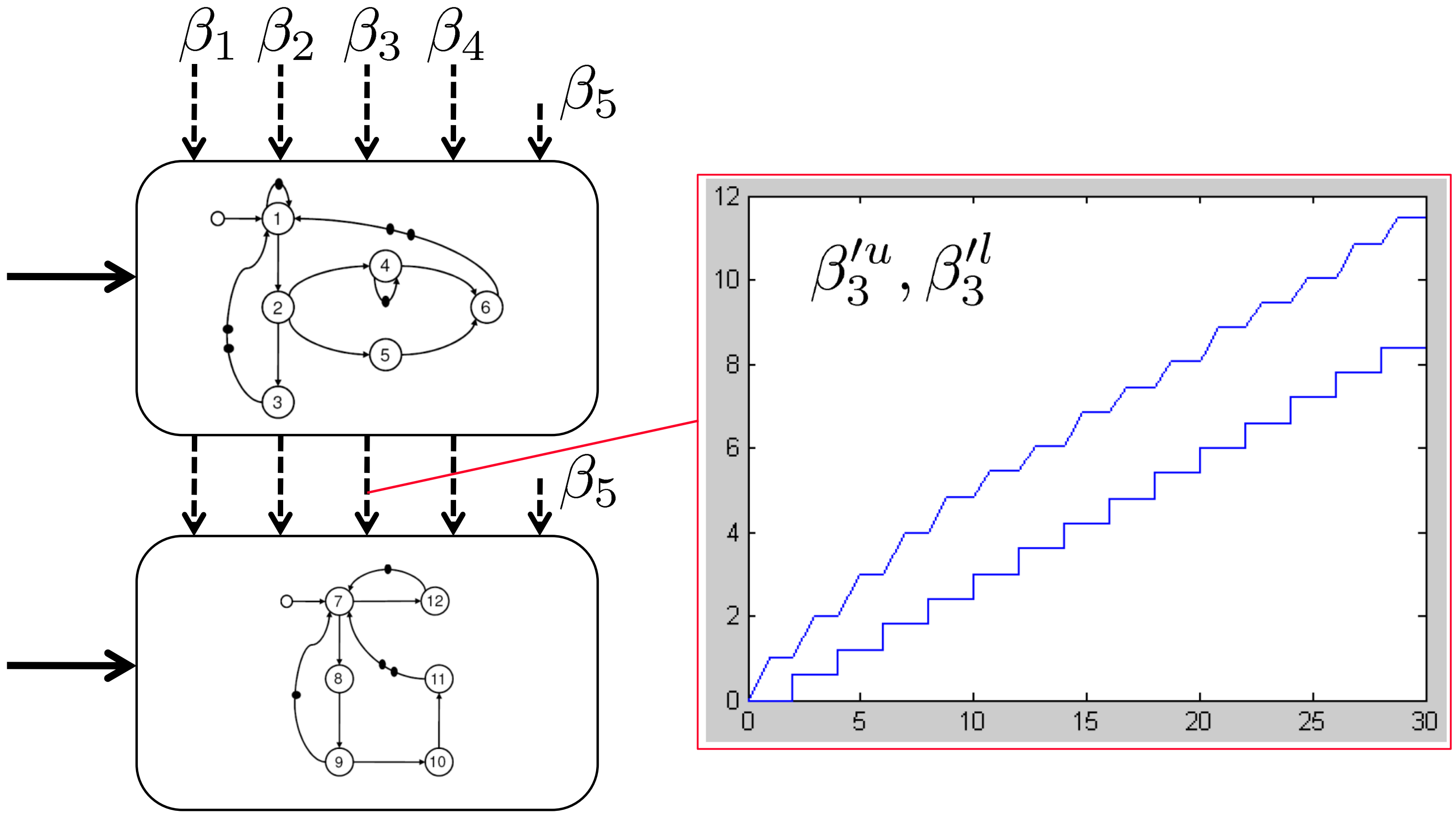
	1	2	3	4	5	6
cycl.	50k	12.5k	20k	3.3k	0.25k	50k
proc.	1	2	5.1	3	4	5.2

	7	8	9	10	11	12
cycl.	2k	0.31k	0.33k	0.42k	4k	2k
proc.	1	2	4	3	5.1	5.2

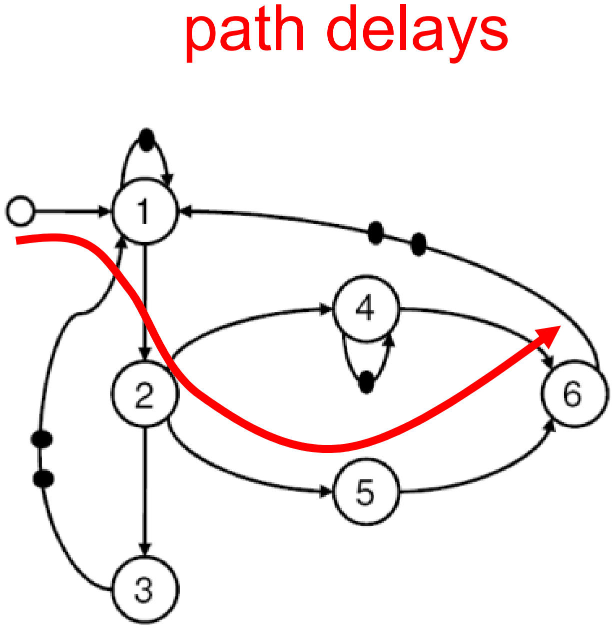
Fixed Priority

TDMA

example



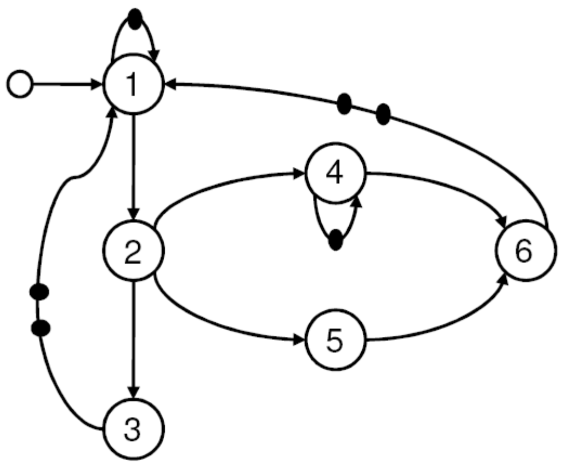
example



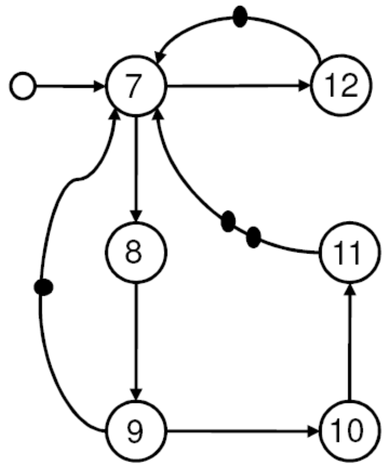
TD-SCDMA

node	delay [ms]
1	0.57
2	0.68
3	0.84
4	0.72
5	0.69
6	1.27

example



TD-SCDMA



WLAN

WLAN

node	delay [ms]
7	0.02
8	0.023
9	0.026
10	0.03
11	0.15
12	0.13

high priority

WLAN

node	delay [ms]
7	24.5
8	31
9	34.5
10	41.3
11	44.7
12	48.2

low priority