



HAL
open science

Matrix-DBP for (m,k) -firm real time guarantee

Ye-Qiong Song

► **To cite this version:**

Ye-Qiong Song. Matrix-DBP for (m,k) -firm real time guarantee. Séminaire du Programme de Recherches Avancées Franco-Chinois PRA SI01-04, Oct 2002, Zhejiang University, China. pp.35. inria-00107605

HAL Id: inria-00107605

<https://inria.hal.science/inria-00107605v1>

Submitted on 19 Oct 2006

HAL is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.

Matrix-DBP For (m, k) -firm Real-Time Guarantee

Based on a common work with E. Poggi, YQ. Song, Z. Wang, A. Koubâa
Partially supported by PRA SI01-04

- Part 1: context
- Part 2: where are the problems
- Part 3: Matrix-DBP
- Part 4: future work

Presentation
at



浙江大学
ZHEJIANG UNIVERSITY

Part 1: (m,k)-firm background

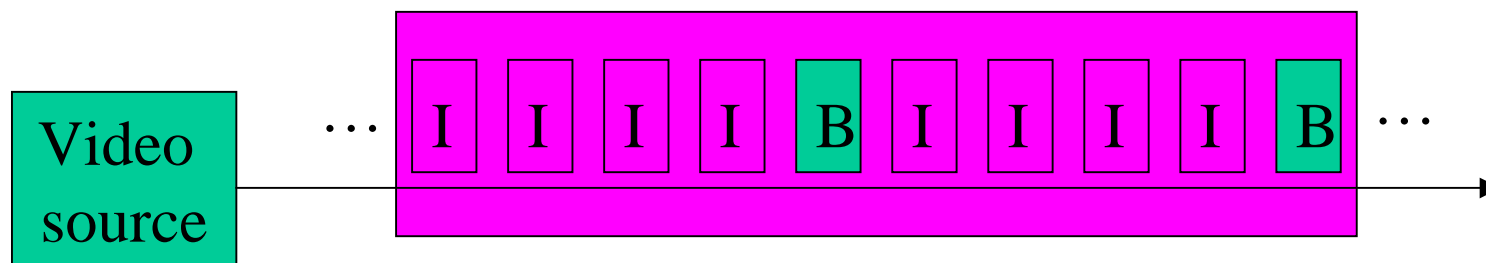


Why we interest in (m,k)-firm?

- HRT uses WC analysis leading to oversized system design (pessimistic performance estimation)
- In practice, many systems being classified HRT are not so « hard ». Occasional deadline misses can be tolerated if they are **correctly distributed**

Why we interest in (m,k)-firm?

- SRT can resolve the over-sizing problem but does not specify **how deadlines can missed**
- A probabilistic guarantee of m/k may not be sufficient (e.g. MPEG video stream composed of I, B and P packets)



Can tolerate at most 1 deadline miss of B every 10 packets

Probability of 9/10 can not be suitable

Why we interest in (m,k)-firm?

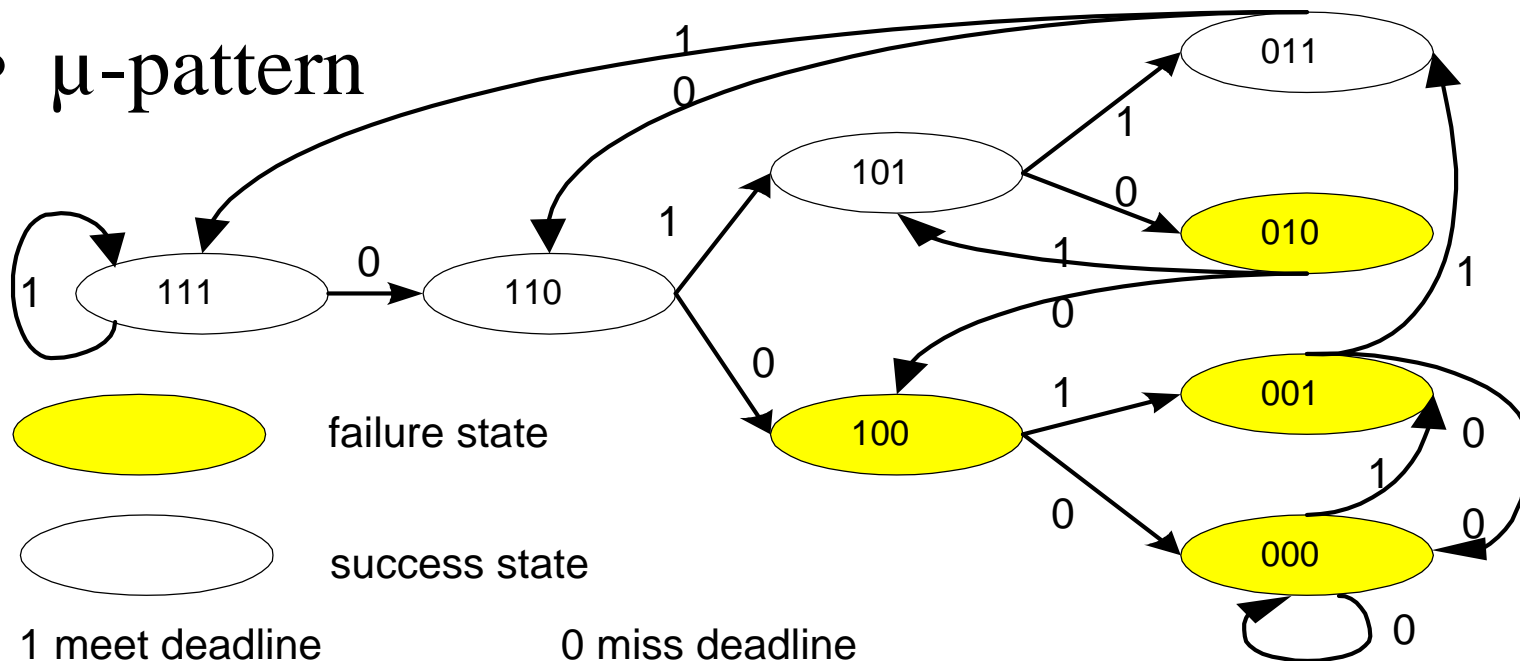
- (m,k)-firm guarantees the deadline meeting of m among any k consecutive task invocations or message transmissions
- (m,k)-firm provides a general frame for RT constraints description :
 - HRT is a particular case of (m,k)-firm with $m=k$
 - SRT guarantee with probability $p = m/k$ is a particular case of (m,k)-firm with: $p = \lim_{m,k \rightarrow \infty} \frac{m}{k}$

(m,k)-firm and WHRT

- (m,k)-firm (i.e. **at least m of k meets**) is firstly introduced by [Hamdaoui95]
- WHRT is defined by [Bernat98] and [Bernat&Burns01] to generalize (m,k)-firm:
 - (\bar{m}, \bar{k}) : **at most m misses**. But $(m, k) = (\bar{k} - \bar{m}, \bar{k})$
 - $\langle m, k \rangle$: in any k consecutive jobs, **at least m consecutive jobs are with deadline meet**
 - $\langle \bar{m}, \bar{k} \rangle = \langle \bar{m} \rangle$: **never m consecutive deadline misses** (notice that $(m, k) \leq \langle \bar{k} - m \rangle$)

(m,k)-firm

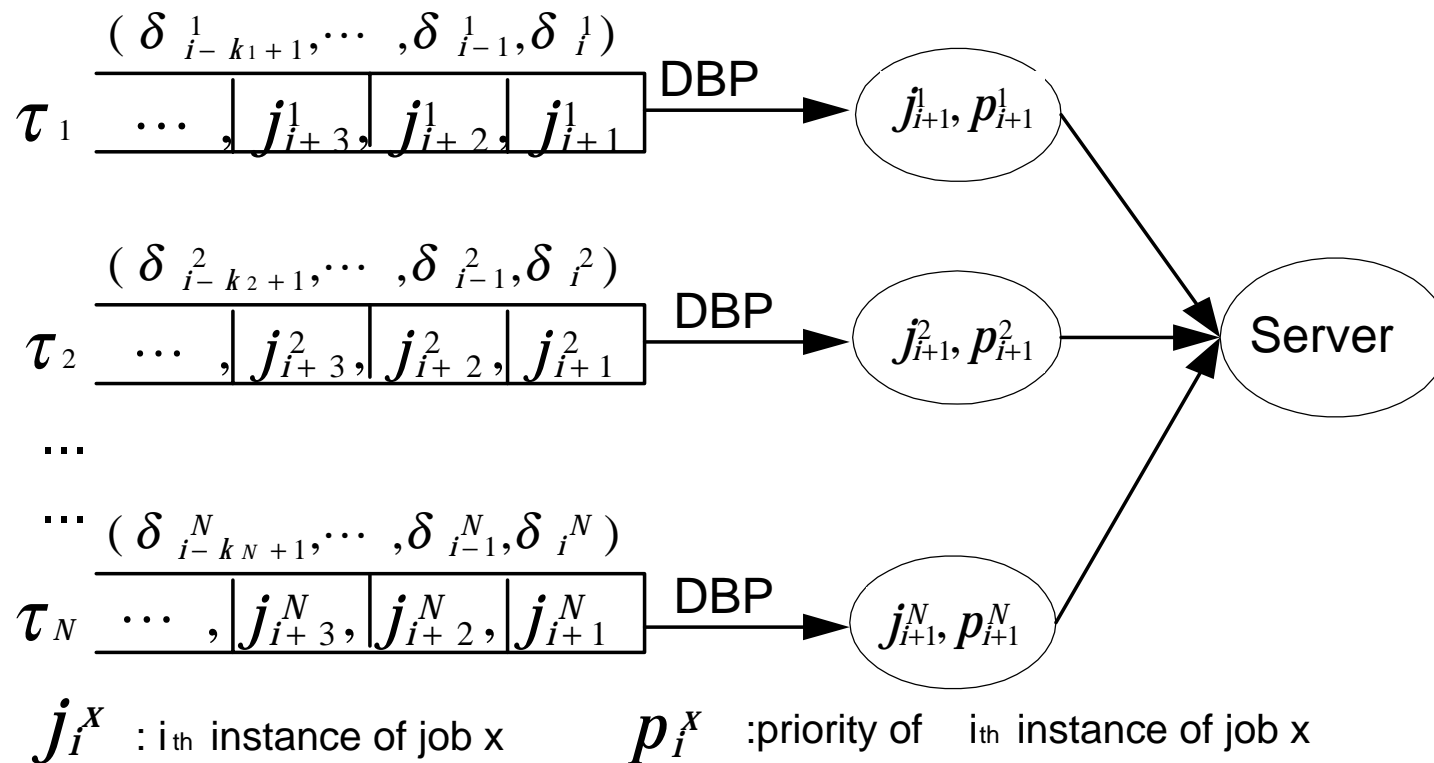
- Failure state in (m,k)-firm context
- Example of (2,3)-firm
- μ -pattern



DBP: Distance Based Priority

- DBP of a μ -pattern is defined as the number of deadline misses to arrive to a failure state
- Example: (3,5)-firm
 - (11011) has a distance of 2
 - (10111) has a distance of 3
 - (10001) has a distance of 0

DBP in MIQSS model



- A job is modeled by: $\tau_i = \{D_i, c_i, m_i, k_i\}$

Gain of DBP for (m,k)-firm

- Dynamic QoS control is possible with:
 - In case of overload, DBP allows on-line drop down of jobs according to (m_i, k_i) , reducing thus the need of resources, i.e.:

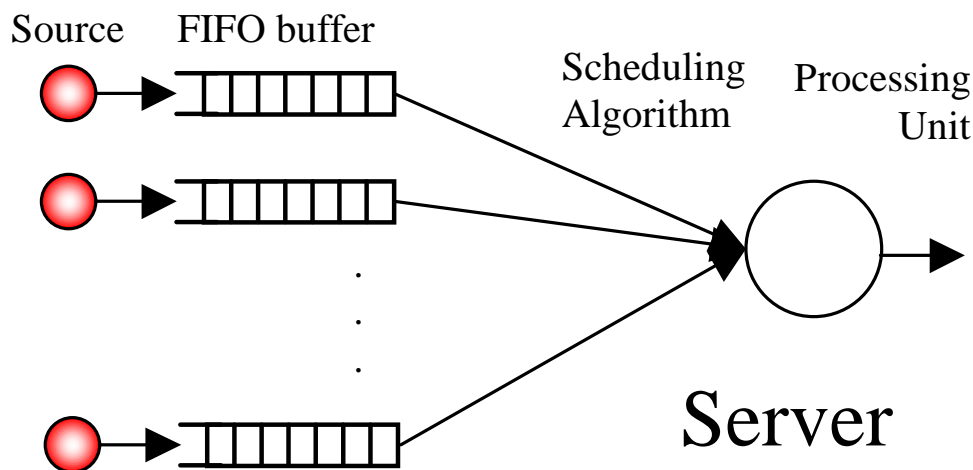
$$\sum_{i=1}^N \left[\frac{c_i}{T_i} \frac{m_i}{k_i} \right] \leq 1 \quad \text{instead of} \quad \sum_{i=1}^N \left[\frac{c_i}{T_i} \right] \leq 1$$

- Can be extended to $(m(t), k(t))$ when on-line scheduling algorithm is adopted

Part 2: where are problems?



Problems of DBP in MIQSS for RT



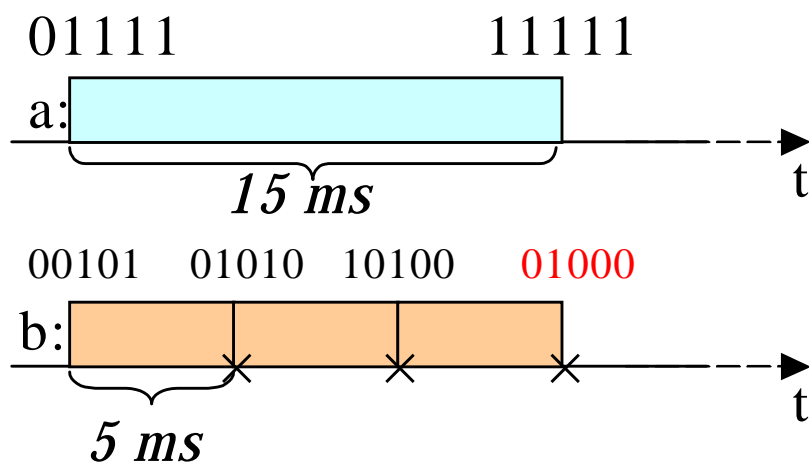
- A job is modeled by: $\tau_i = \{T_i, D_i, c_i, m_i, k_i\}$
- Pb1: how to choose when several jobs have the same priority? (DBP+EDF?)
- Pb2: how to take into account the relative importance among jobs of all sources ?

Un example of Pb2

	(m,k)-constraint	Service time (ms)	Period/Deadline	Initial μ -pattern
Sa	(4,5)	15	30	{01111}
Sb	(2,5)	2	5	{00101}

2

3



processing firstly Sa will lead to failure state of Sb !

So notion of relative criticality should be defined

Need of new *non-preemptive* scheduling algo.

- Should take into account:
 - (m,k)-firm constraint
 - Other temporal parameters & constraints: T_i , D_i , c_i
 - Relative criticality between streams (a matrix can be used to represent it)
- Should be of low implementation cost

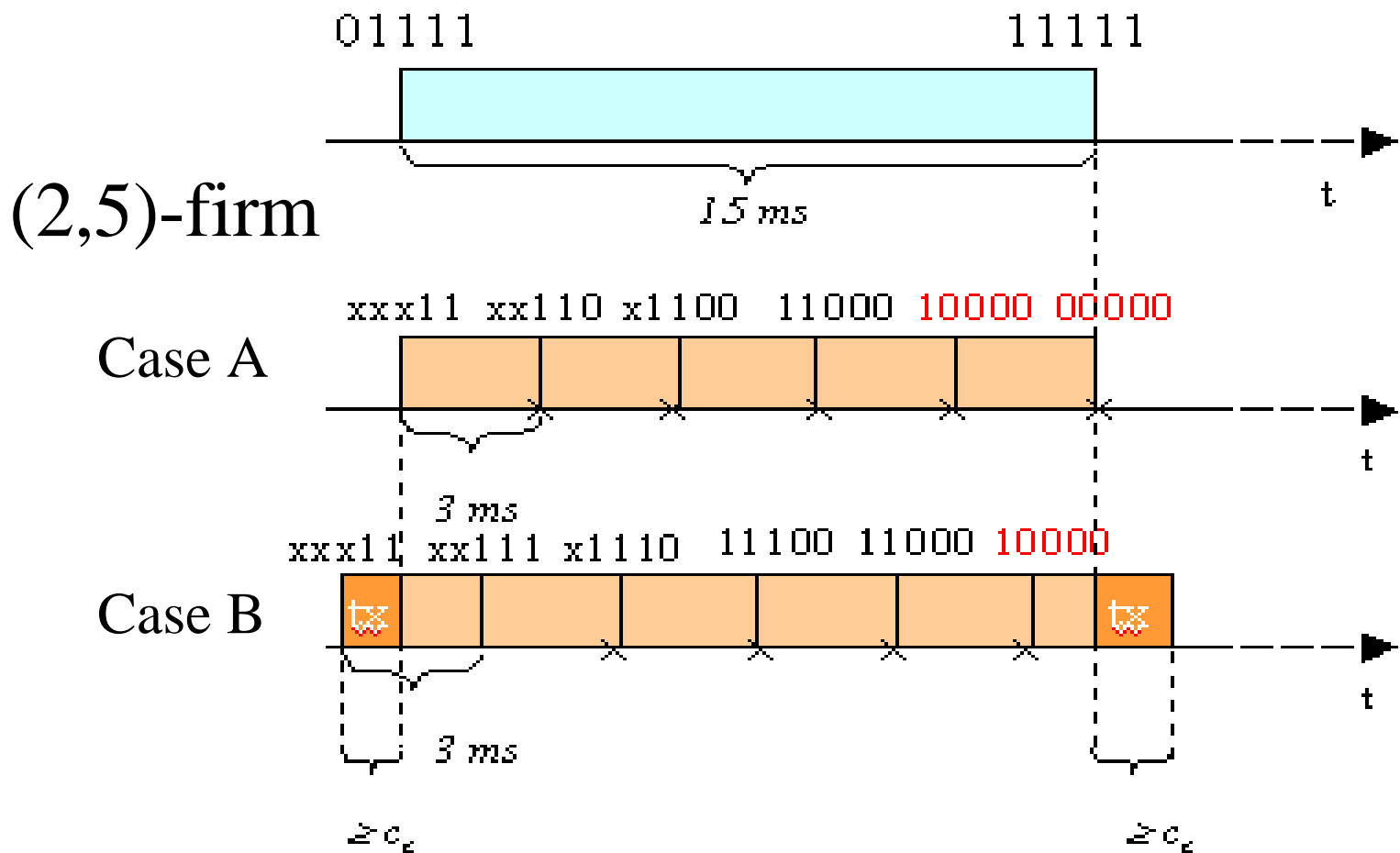


Matrix-DBP can meet all these requirements

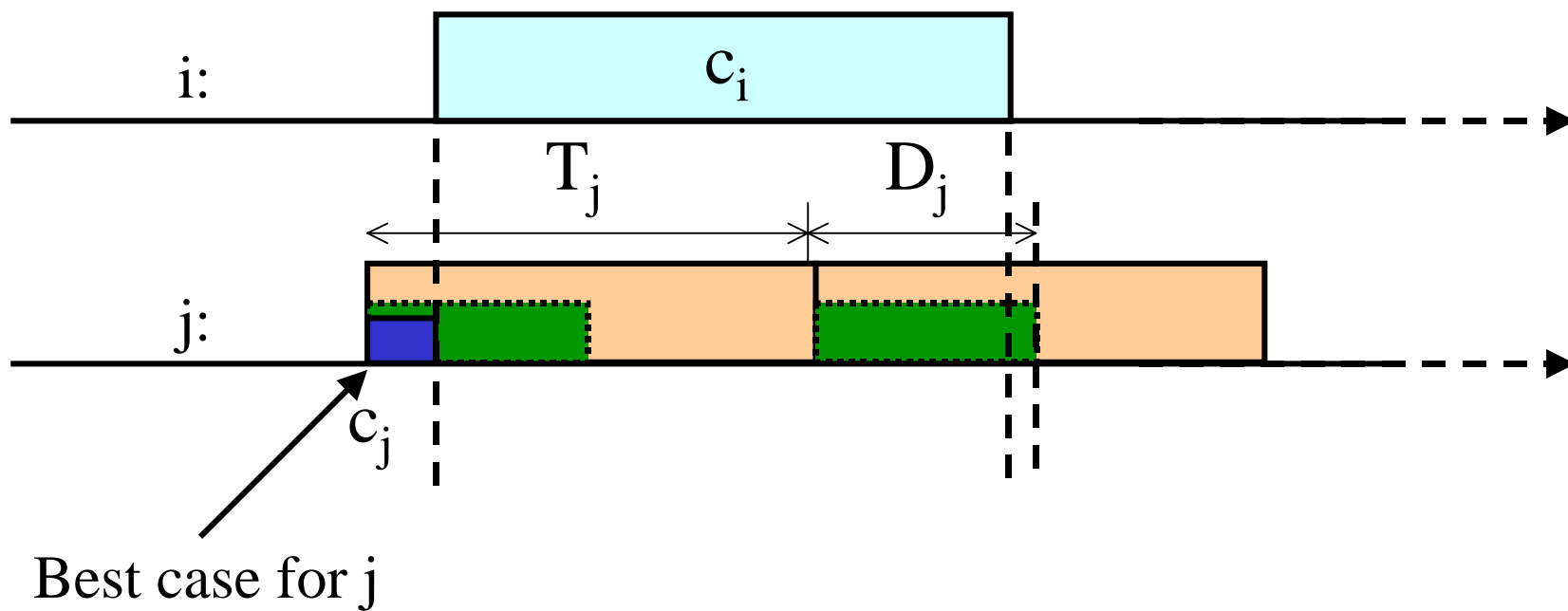
Part 3: Matrix-DBP



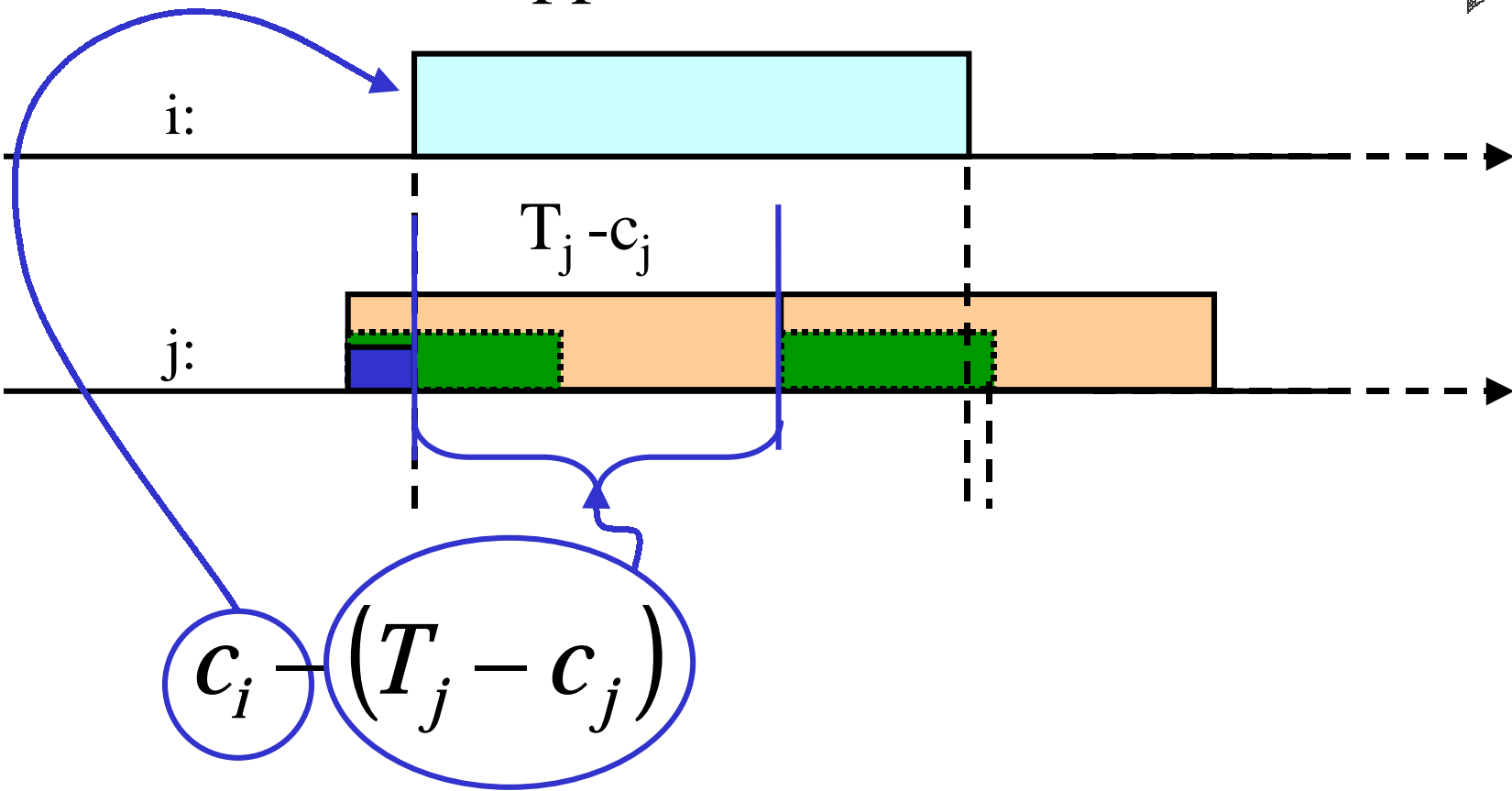
Offset between jobs invocations



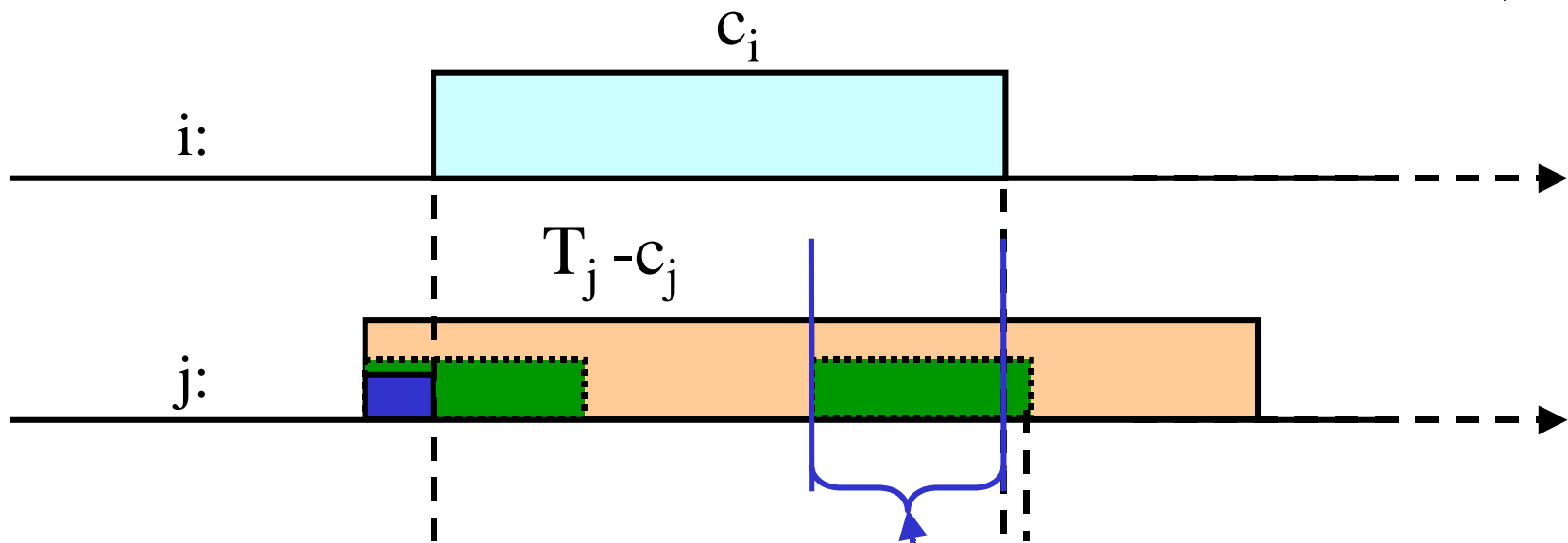
When happens 1 deadline miss



When happens 1 deadline miss

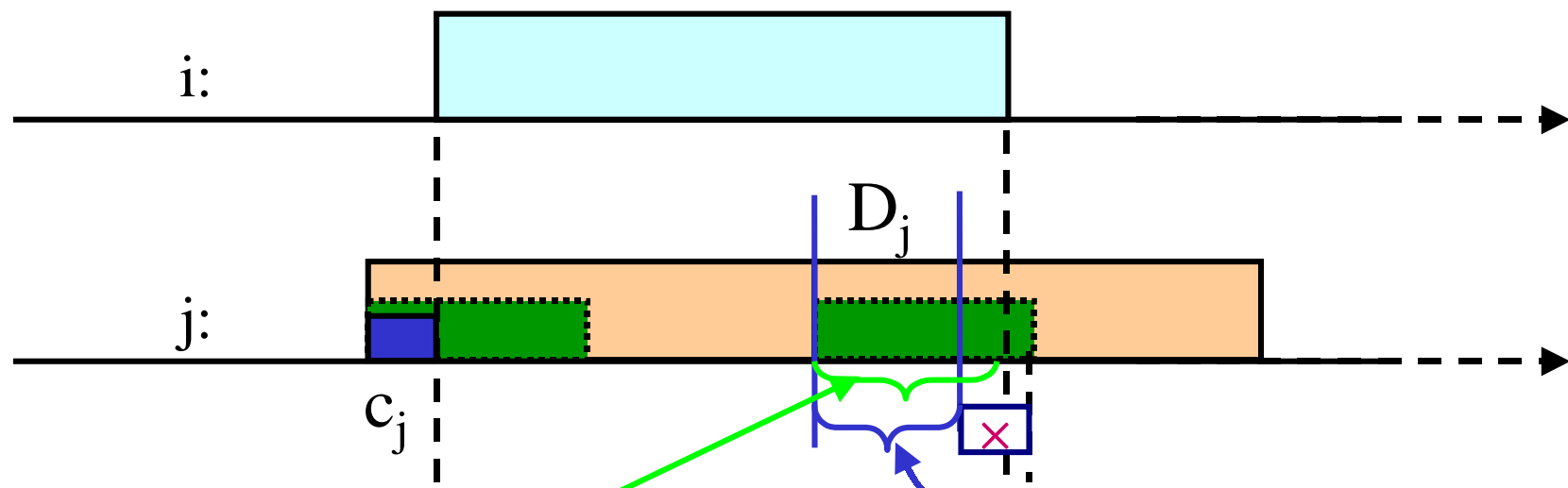


When happens 1 deadline miss



$$c_i - (T_j - c_j)$$

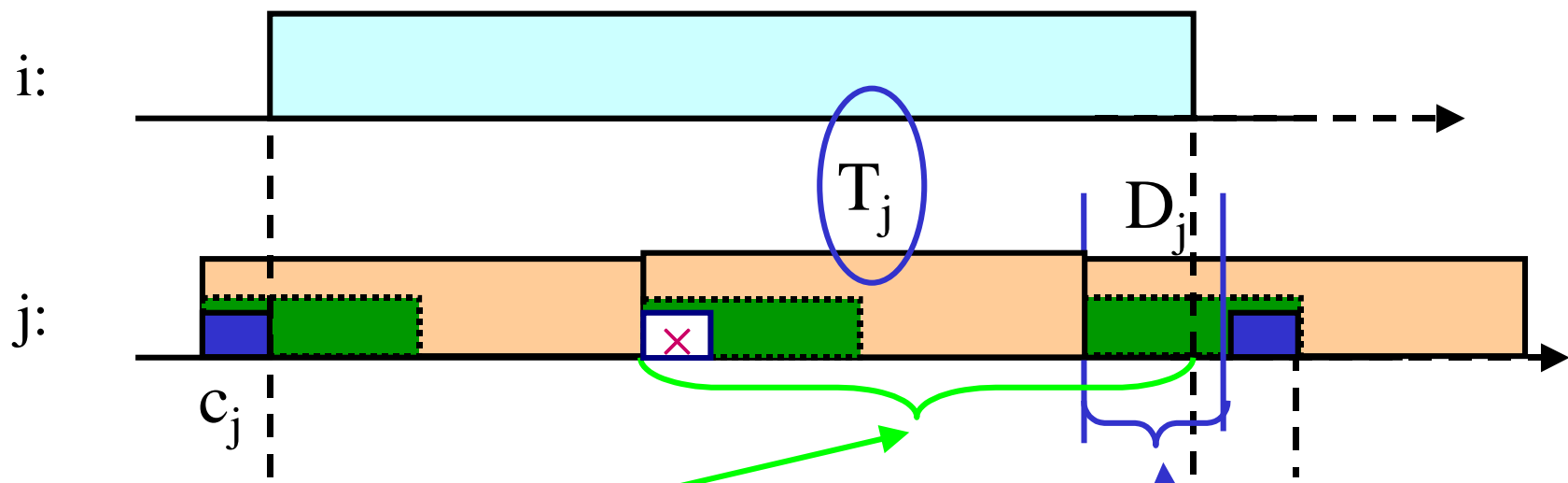
When happens 1 deadline miss



if $c_i - (T_j - c_j) > D_j - c_j$ then 1 miss in the best case.

i.e., at least 1 miss

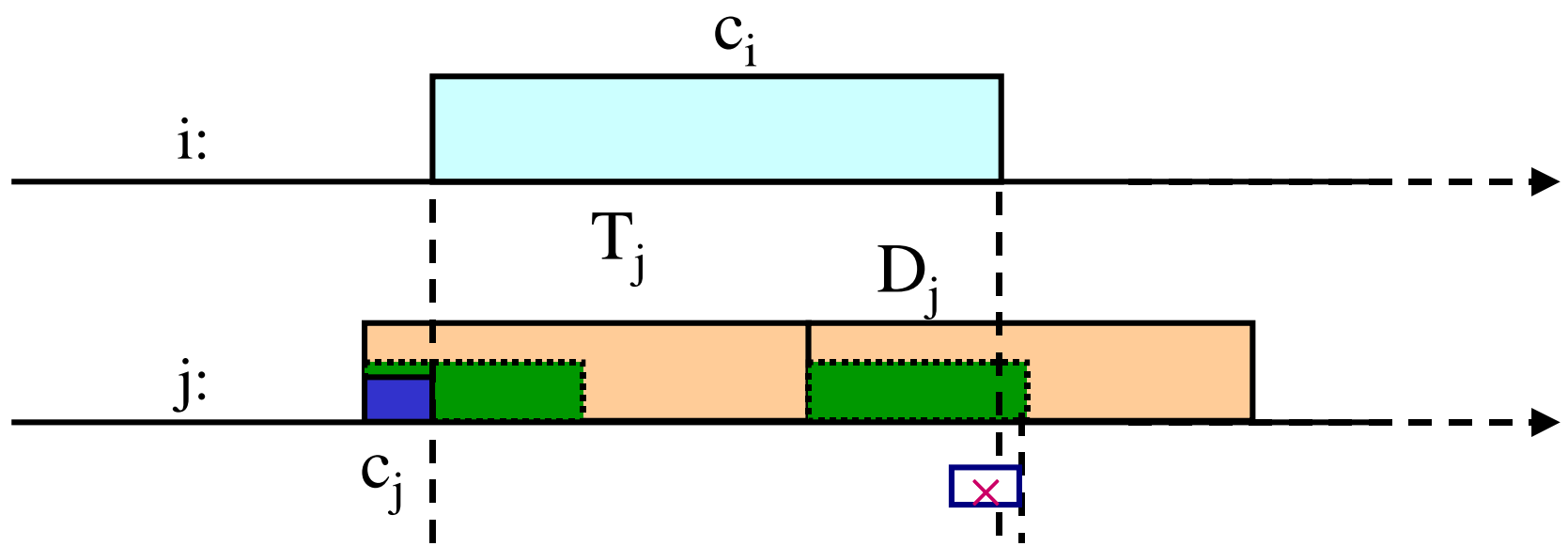
When happens 1 deadline miss



if $c_i - (T_j - c_j) \leq T_j + D_j - c_j$

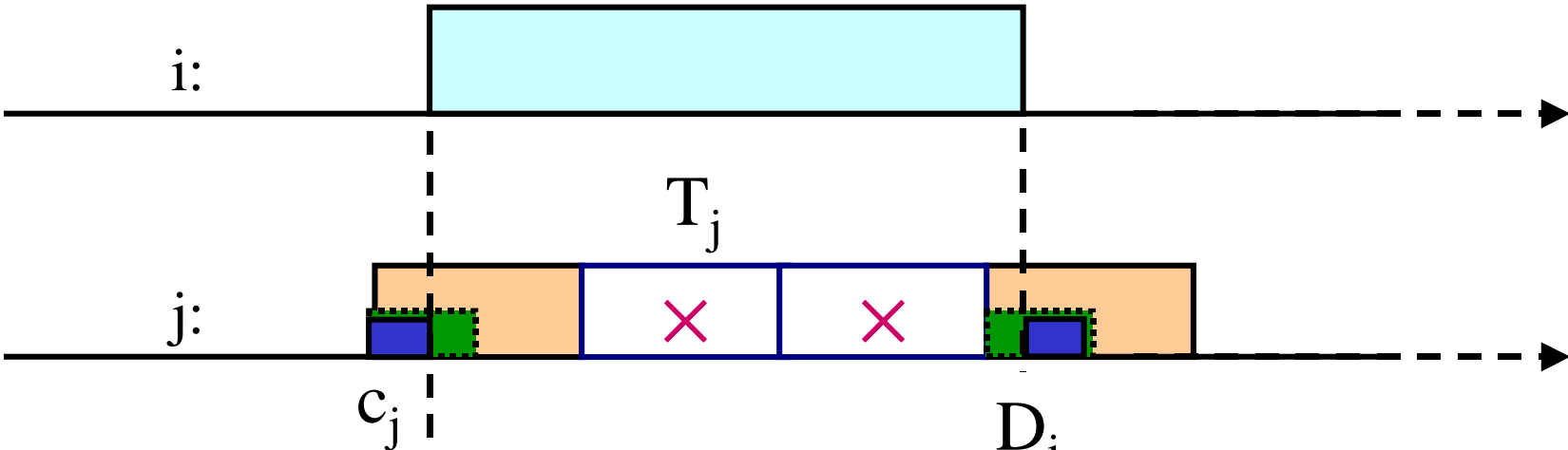
then no more than 1 miss

When happens 1 deadline miss



$$\left\{ \begin{array}{l} c_i - (T_j - c_j) > D_j - c_j, \quad \text{At least 1 miss} \\ c_i - (T_j - c_j) \leq T_j + D_j - c_j. \quad \text{No more than 1 miss} \end{array} \right.$$

Generalization to n deadline misses



$$\left\{ \begin{array}{l} c_i - (T_j - c_j) > (n_{j,i} - 1) \cdot T_j + D_j - c_j, \\ c_i - (T_j - c_j) \leq n_{j,i} \cdot T_j + D_j - c_j. \end{array} \right.$$

which gives $x-1 \leq n < x$

Minimum number of deadline misses

$$n_{j,i} = \left\lceil \frac{c_i + 2c_j - D_j}{T_j} \right\rceil - 1.$$

Minimum number of jobs that stream j misses while a job of stream i is being served

$$M = \begin{bmatrix} \cdot & \cdot & \cdot & \cdot \\ n_{j,i} & \cdot & \cdot & \cdot \\ \cdot & \cdot & \cdot & \cdot \\ \cdot & \cdot & \cdot & \cdot \end{bmatrix} \left. \vphantom{\begin{bmatrix} \cdot & \cdot & \cdot & \cdot \\ n_{j,i} & \cdot & \cdot & \cdot \\ \cdot & \cdot & \cdot & \cdot \\ \cdot & \cdot & \cdot & \cdot \end{bmatrix}} \right\} N \times N$$

Necessary conditions

Necessary Load condition

$$\sum_{i=1}^N \left[\frac{c_i}{T_i} \frac{m_i}{k_i} \right] \leq 1$$

Mutual feasibility condition

$$\forall i, j \leq N,$$

$$n_{i,j} \leq k_i - m_i$$

New
Necessary
Condition

Matrix-DBP

	(m, k)	Execution time	Period Deadline	Initial μ -pattern	Priority
Stream a	(4, 5)	15ms	30ms	01111	2
Stream b	(2, 5)	2ms	5ms	00101	3

$$M = \begin{bmatrix} 0 & 0 \\ 2 & 0 \end{bmatrix}$$

$$\text{Priority}_{a,b} = \text{DBP}_a - n_{a,b} = 2$$

$$\text{Priority}_{b,a} = \text{DBP}_b - n_{b,a} = 1$$



Simulation scenario

	(m,k)- constraints	Job Process time: c_i	Period (T_i)/ Deadline(D_i)
Stream 0	(2,5)	8/c	12
Stream 1	(4,5)	10/c	20
Stream 2	(3,6)	2/c	5
Stream 3	(1,5)	4/c	6

Matrix of the scenario

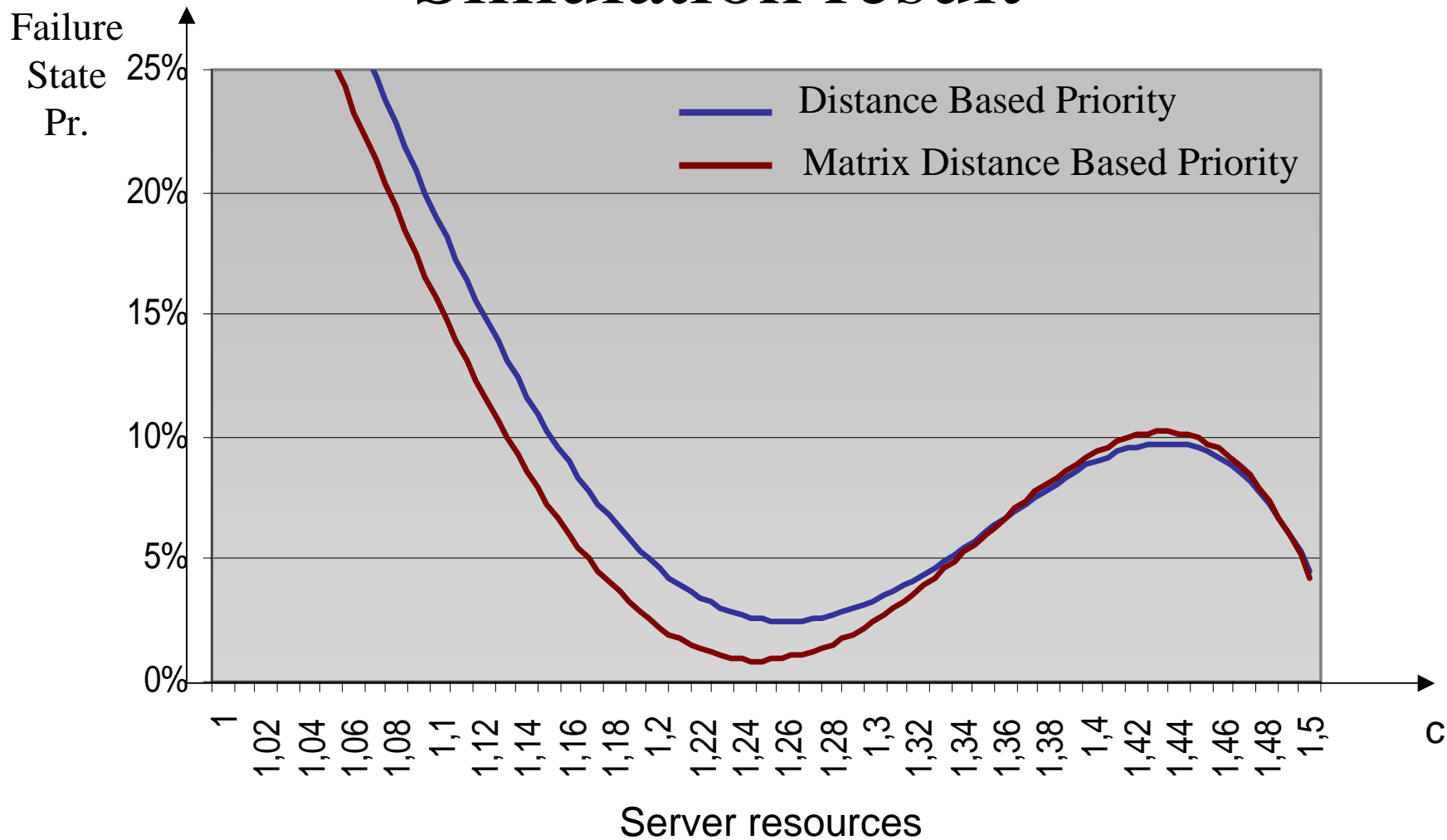
- When $c = 1$

$$M = \begin{bmatrix} 0 & 1 & 0 & 0 \\ 0 & 0 & 0 & 0 \\ 1 & 1 & 0 & 0 \\ 1 & 1 & 0 & 0 \end{bmatrix}$$

- When $c = 1.5$
Matrix-DBP
becomes DBP

$$M = \begin{bmatrix} 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 \end{bmatrix}$$

Simulation result



Contributions on (m,k)-firm

- Pointed out the drawback of the classic DBP when it is applied to a more general real-time context
- Provided an additional necessary condition call mutual schedulability test
- Proposed matrix-DBP to correct DBP

Part 4: Future work

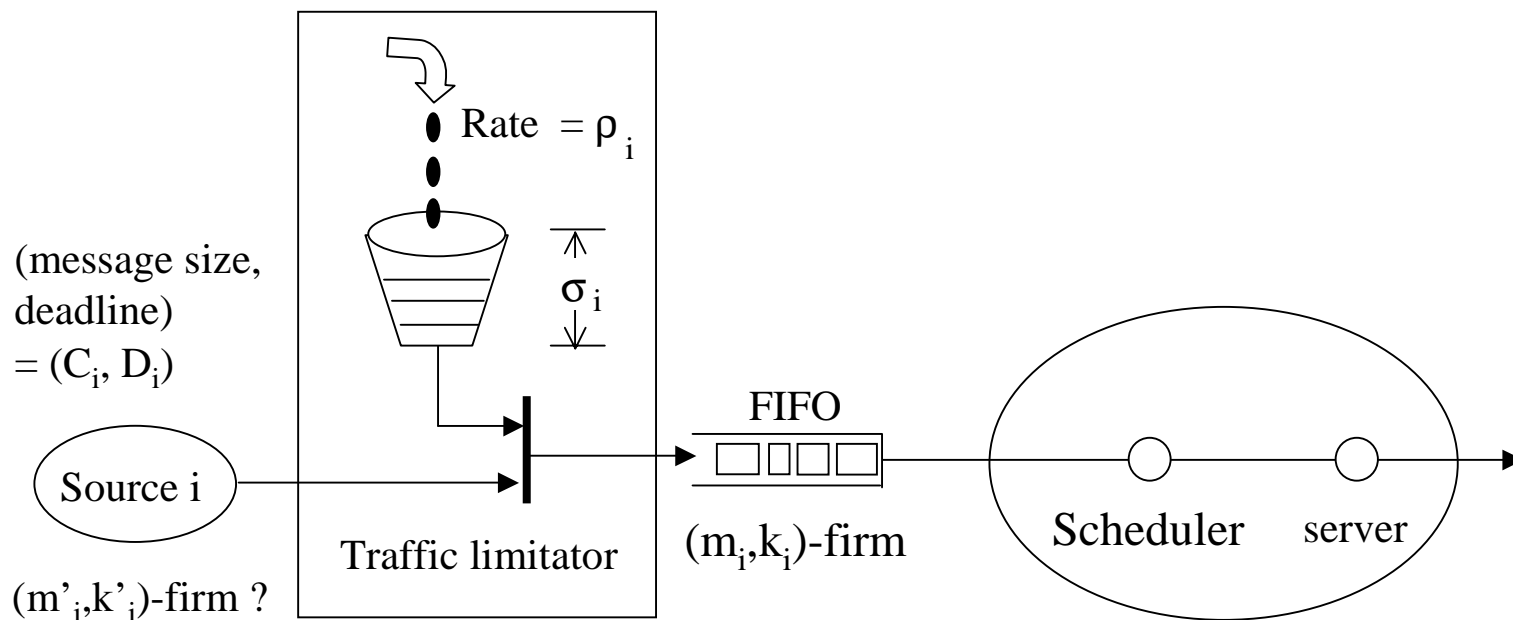


On Matrix-DBP for (m,k) -firm

- Analysis of necessary condition on c for (m,k) -firm guarantee (i.e. find the value of c from which the system always has \emptyset failure state)
- Taking other criteria than the global failure state percentage (e.g., fairness in failure state percentage for each stream)
- Extension to multi-hops case by taking global deadline and local deadlines

On (m,k) -firm

- Enhancement of DBP for aperiodic streams
- (m,k) -firm for a (σ, ρ) upper bounded traffic



Application domains of (m,k)-firm

- Handling real-time traffic in Switched Industrial Ethernet (an Intranet) and in Internet
- Evaluating dependability in process control systems (in which we suppose that the state variables are over-sampled vs. Nyquist frequency)

Questions and remarks?

