Department of Telecommunications

# Resource (Re)allocation and Admission Control for Adaptive Multimedia Services

*Krunoslav Ivesic, Maja Matijasevic, Lea Skorin-Kapov*

University of Zagreb, Faculty of Electrical Engineering and Computing

Unska 3, Zagreb, Croatia

*krunoslav.ivesic@fer.hr*

CSWS 2011

# Outline



- Problem description
- Media degradation path
- Resource allocation
- Admission control
- Conclusions and future work

# Problem description

- Multimedia services
  - Two or more media components
  - Complex Quality of Service (QoS) management due to service dynamics

- Potentially very high resource consumption

- Our goal: to provide description for such services, analyze service dynamics and create appropriate mechanisms for admission control and resource (re)allocation

# Service description

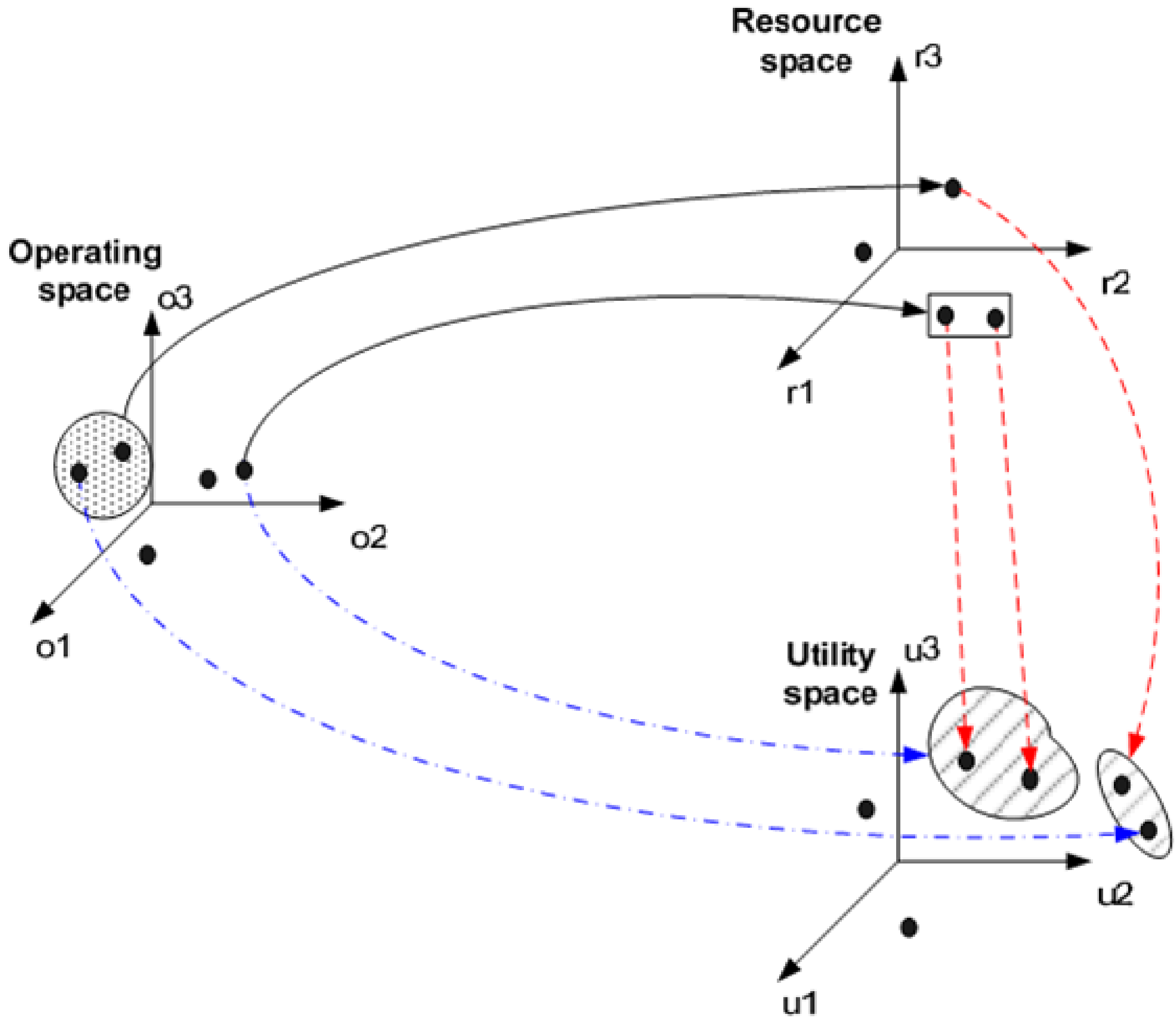


- For services with several flows, users' preferences regarding flow importance:
  - May vary
  - Should be considered at session initiation time

- Appropriate service description: Media Degradation Path (MDP)
  - A list of service *configurations*
  - Each configuration consists of operating parameters, resource requirements and *utility* value (a numerical indicator of user's satisfaction)

# Media degradation path: origin

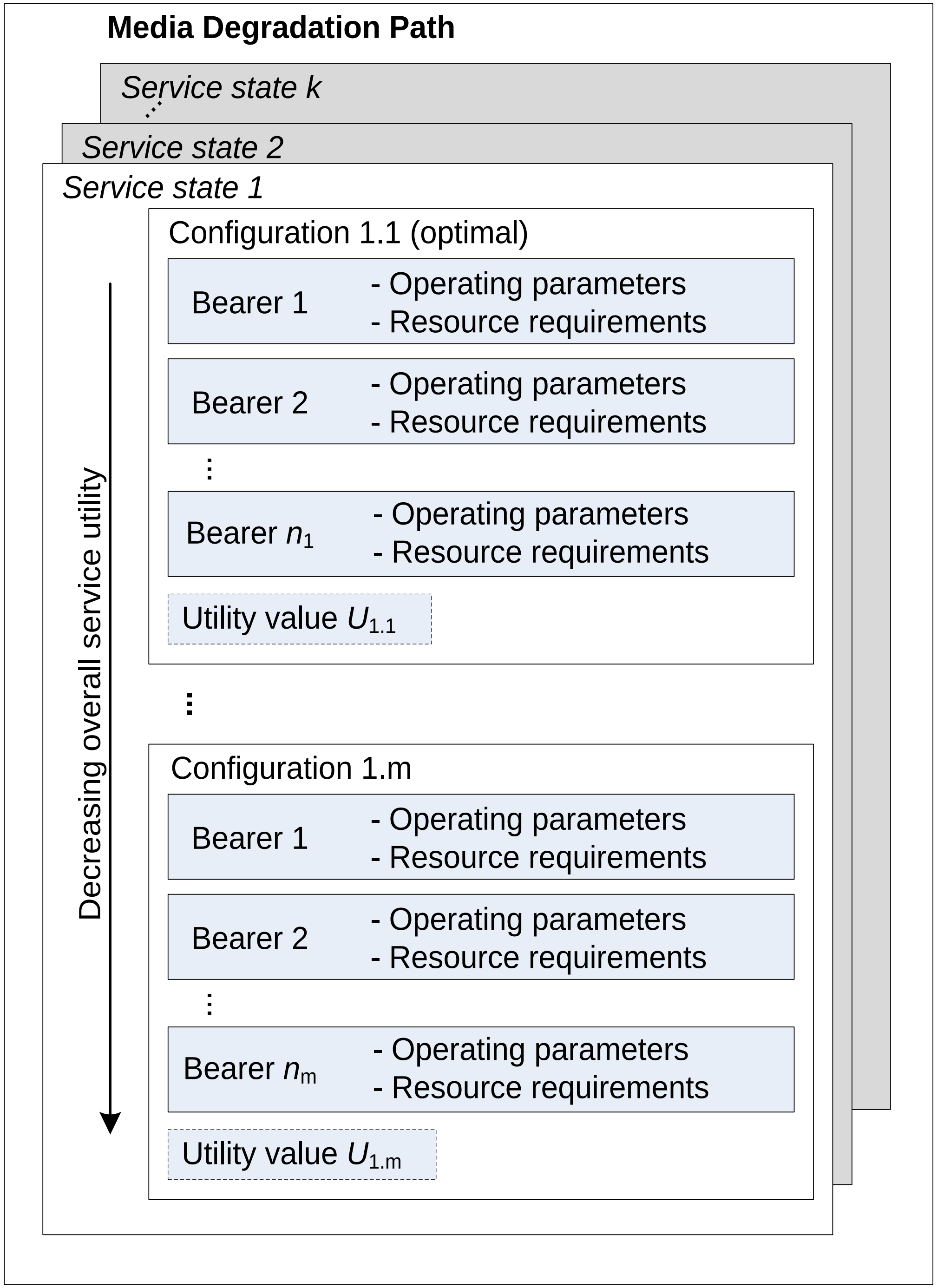





Mapping between adaptation, resource and utility spaces

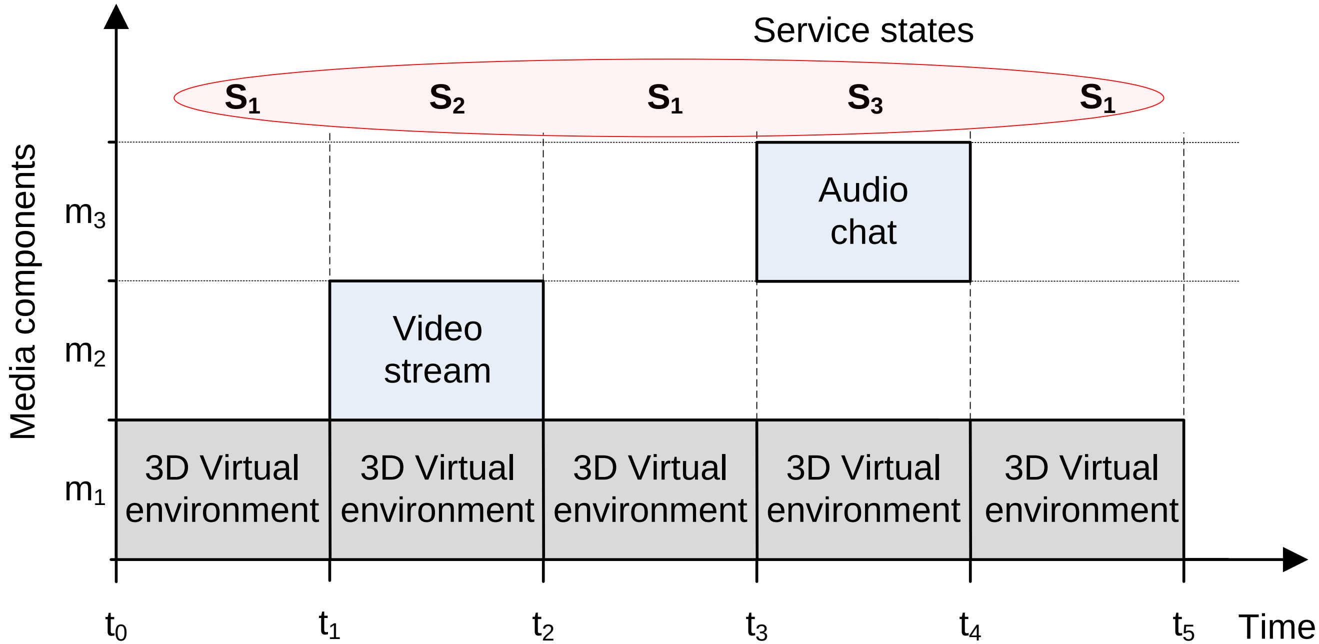
L. Skorin-Kapov and M. Matijasevic, "A data specification model for multimedia QoS negotiation," in MobiMedia '07: Proc. of the 3rd Int. Conf. on Mobile Multimedia communications, (Nafpaktos, Greece), pp. 1–7, ICST, 2007.

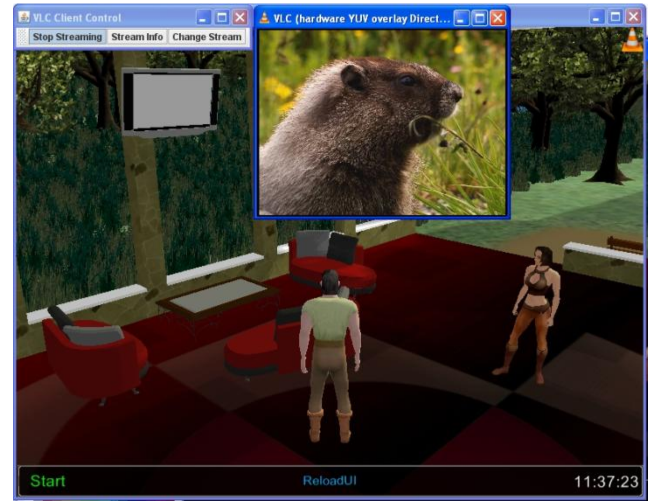
# Media degradation path - scheme



# MDP – Service states

Department of Telecommunications




An example scenario of a service with three states

# Resource reallocation



- In case of significant decrease in resource availability:
  - Switch active sessions to less resource demanding configurations from current states of their MDPs
  - Maximize the total utility, while considering priorities of users and services, subject to resource demands
  - Mathematical formulation: multi-choice multidimensional 0-1 knapsack problem (MMKP), NP-complete

# Resource reallocation: mathematical formulation

Department of Telecommunications

- Number of currently active sessions: $n$
- Number of configurations in MDP of session $u$: $p_u$
- Flows of configuration $ui$: $1, \ldots, h_{ui}, h_{ui} + 1, \ldots, z_{ui}$
- Bandwidth requirements for configuration $ui$:

  $\mathbf{b}_{ui} = (\mathbf{b}_{ui1}, \ldots, \mathbf{b}_{uiz_{ui}})$, where $\mathbf{b}_{uij} = (\mathrm{b}_{uij1}, \ldots, \mathrm{b}_{uij9})$
- Configuration's utility, revenue and cost: $U_{ui}(\mathbf{b}_{ui})$, $R_{ui}(\mathbf{b}_{ui})$, $C_{ui}(\mathbf{b}_{ui})$. Normalization:

$$U\_n_{ui}(\mathbf{b}_{ui}) = \frac{U_{ui}(\mathbf{b}_{ui})}{U_{u1}(\mathbf{b}_{u1})}$$

- Weight factor: $w_u = w_u^{category} \cdot w_u^{service}$

# Resource reallocation: mathematical formulation (2)

Department of Telecommunications

- Users' utility:

$$F_{ut} = \sum_{u=1}^{n} \sum_{i=1}^{p_u} \left\{ w_u x_{ui} U\_n_{ui} (\mathbf{b}_{ui}) \right\}$$

- Operator's utility:

$$F_{op} = \sum_{u=1}^{n} \sum_{i=1}^{p_u} w_u x_{ui} \frac{R_{ui}(\mathbf{b}_{ui}) - C_{ui}(\mathbf{b}_{ui})}{\max_i \left[ R_{ui}(\mathbf{b}_{ui}) - C_{ui}(\mathbf{b}_{ui}) \right]}$$

- The goal is to maximize the total utility

$$\max \left( w_{utility} F_{ut} + w_{profit} F_{op} \right)$$

such that bandwidth constraints are fulfilled.

# Resource reallocation: mathematical formulation (3)



- The bandwidth constraints:

$$\sum_{u=1}^{n}\sum_{i=1}^{p_u}\sum_{j=1}^{h_{ui}} x_{ui} b_{uijk} \leq B_{k\_DL}, \; k = 1, \ldots, 9$$

$$\sum_{u=1}^{n}\sum_{i=1}^{p_u}\sum_{j=h_{ui}+1}^{z_{ui}} x_{ui} b_{uijk} \leq B_{k\_UL}, \; k = 1, \ldots, 9$$

$$\sum_{i=1}^{p_u} x_{ui} = 1, \; x_{ui} \in \{0,1\}, \; u = 1, \ldots, n$$

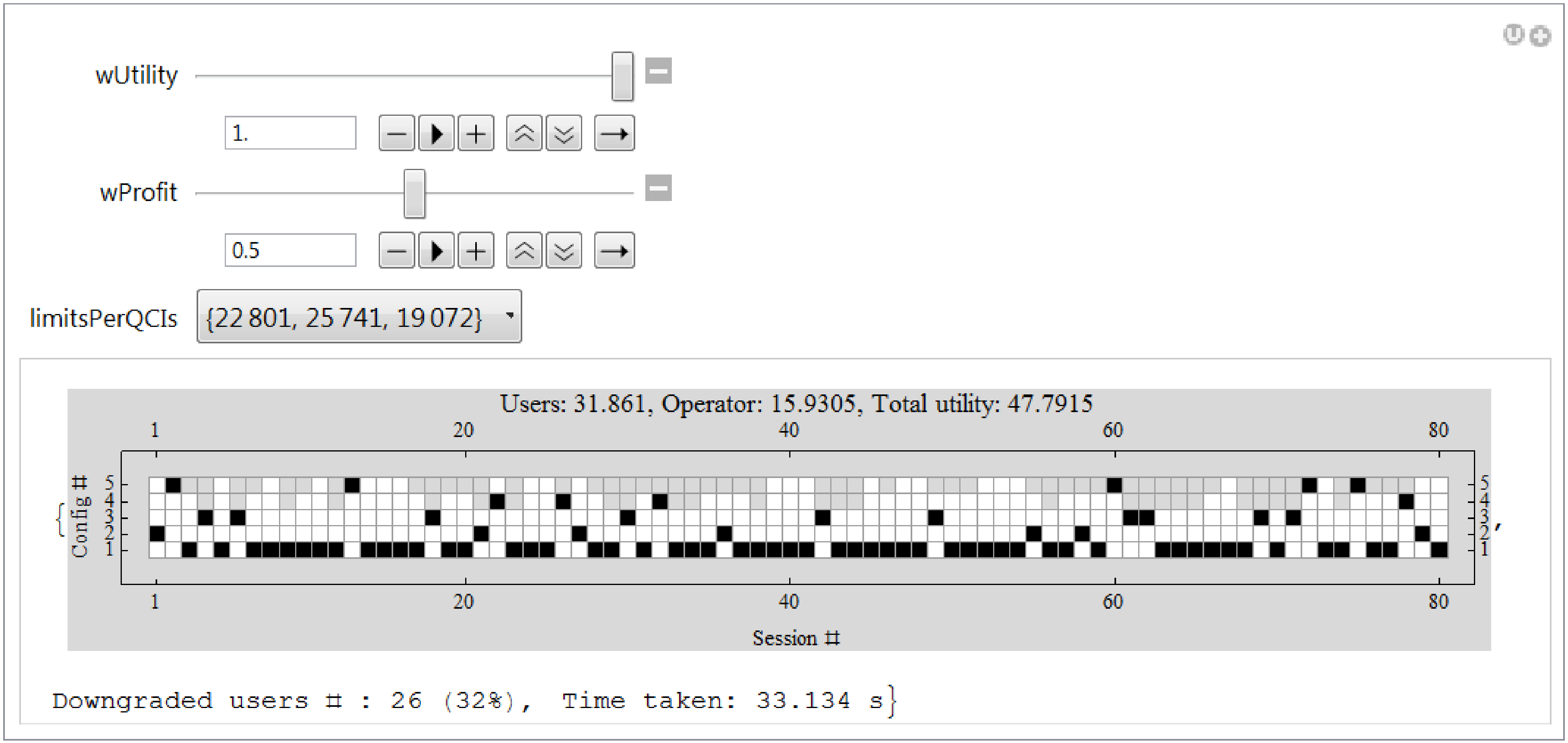
# Implementation in *Mathematica*



- Random generation of sessions in Wolfram *Mathematica* 7.0
  - Optimal configuration and several suboptimal configurations with decreasing bandwidth requirements and some flows dropped
  - Utility, revenue and cost as functions of requirements, normalized to enable fair comparison
  - Gradual decrease of the bandwidth to 90%, 80%, ..., 40% of max. requirements

# GUI in *Mathematica*

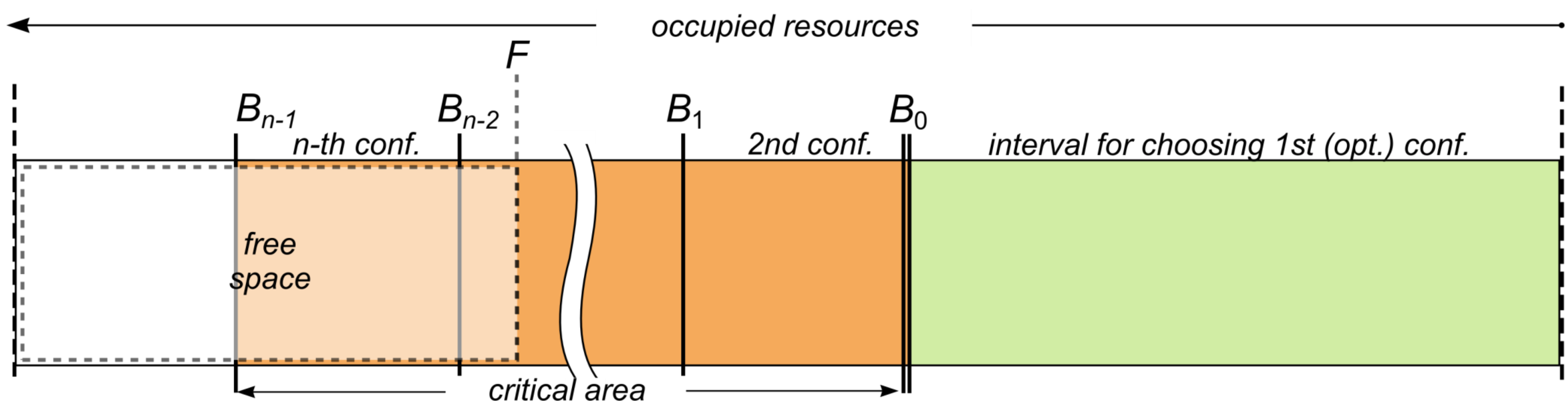




# Admission control



- In case of decreased resource availability new sessions can be admitted with lower quality configurations from their MDPs, rather then being entirely rejected



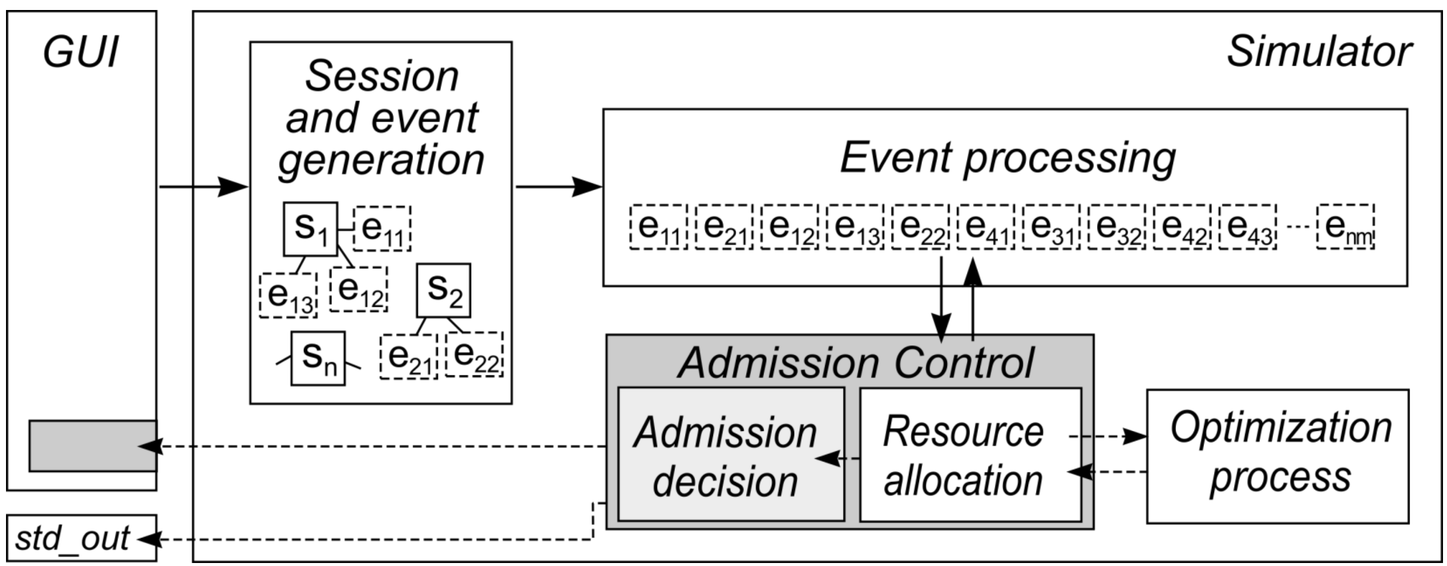
# Admission control (2)

- Handling state changes
  - If session changes its state, the configuration to be activated in the new state is:
    - The optimal one, if the session has been admitted with the optimal configuration from the first active state
    - One of the suboptimal configurations, if the session has been admitted with one of the alternative configurations from the first active state

# Putting it all together: simulation

Department of Telecommunications
FER

- A simulator tool named ADAPTISE (ADmission control and resource Allocation for adaPtive mulTImedia SErvices)
  - Simulates multimedia session arrivals, durations, resource allocation and state changes



# ADAPTISE GUI

Department of Telecommunications
FER

# Admission control and resource reallocation together?



- Is degradation of existing sessions justifiable?

- Suggestion:
  - Reserve a portion of resources for handoff and state changes
  - Degrade only those sessions that have increased their resource consumption considerably since their admission (due to state changes)

# Conclusions



- MDP is a suitable descriptor for adaptive multimedia services
  - Improves admission probability since it enables admission with a suboptimal configuration
  - Resource reallocation based on the MDP improves resource management for dynamic multimedia sessions with variable flow number