



# 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

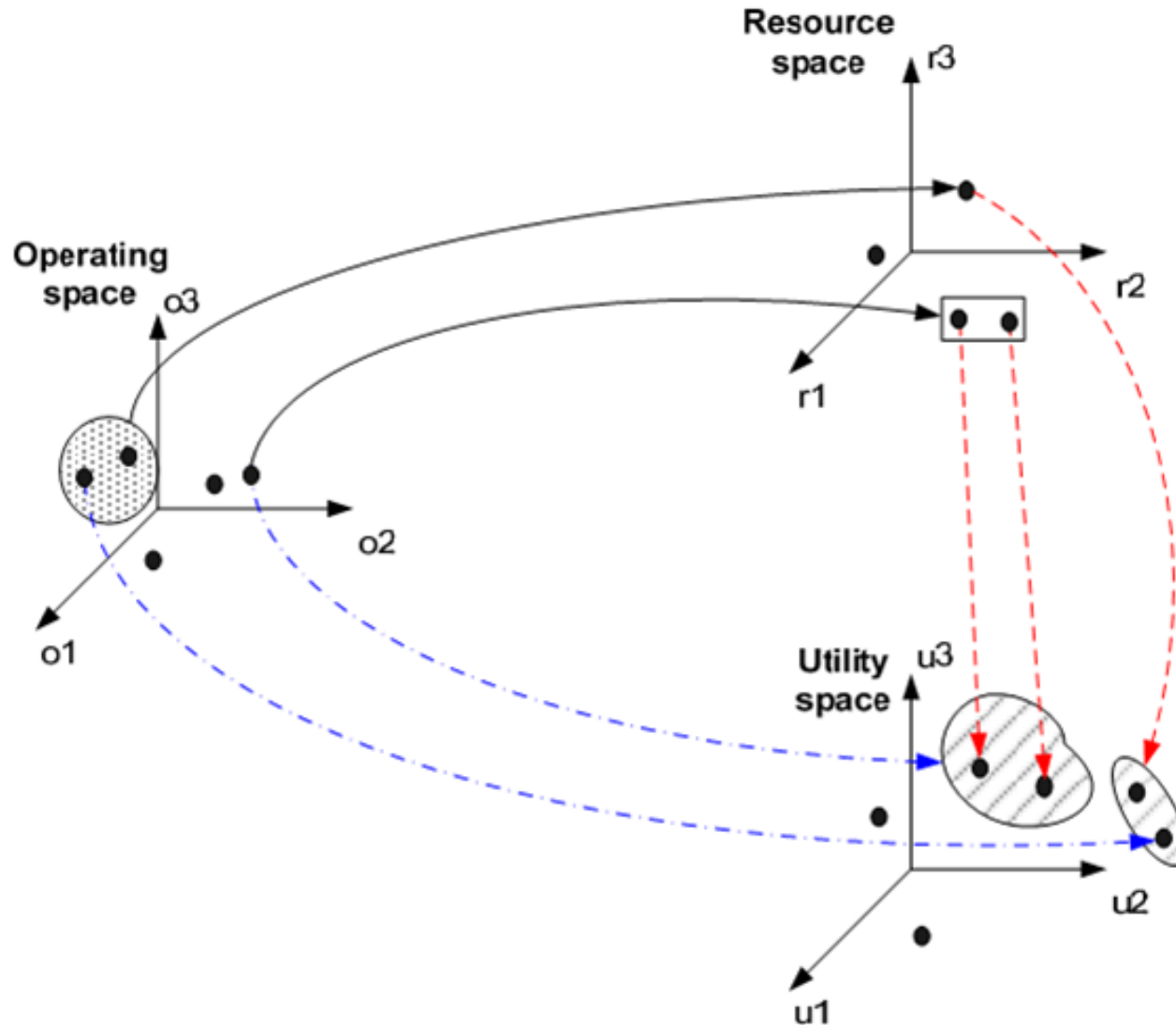
Unska 3, Zagreb, Croatia

*krunoslav.ivesic@fer.hr*

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

- ◆ 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

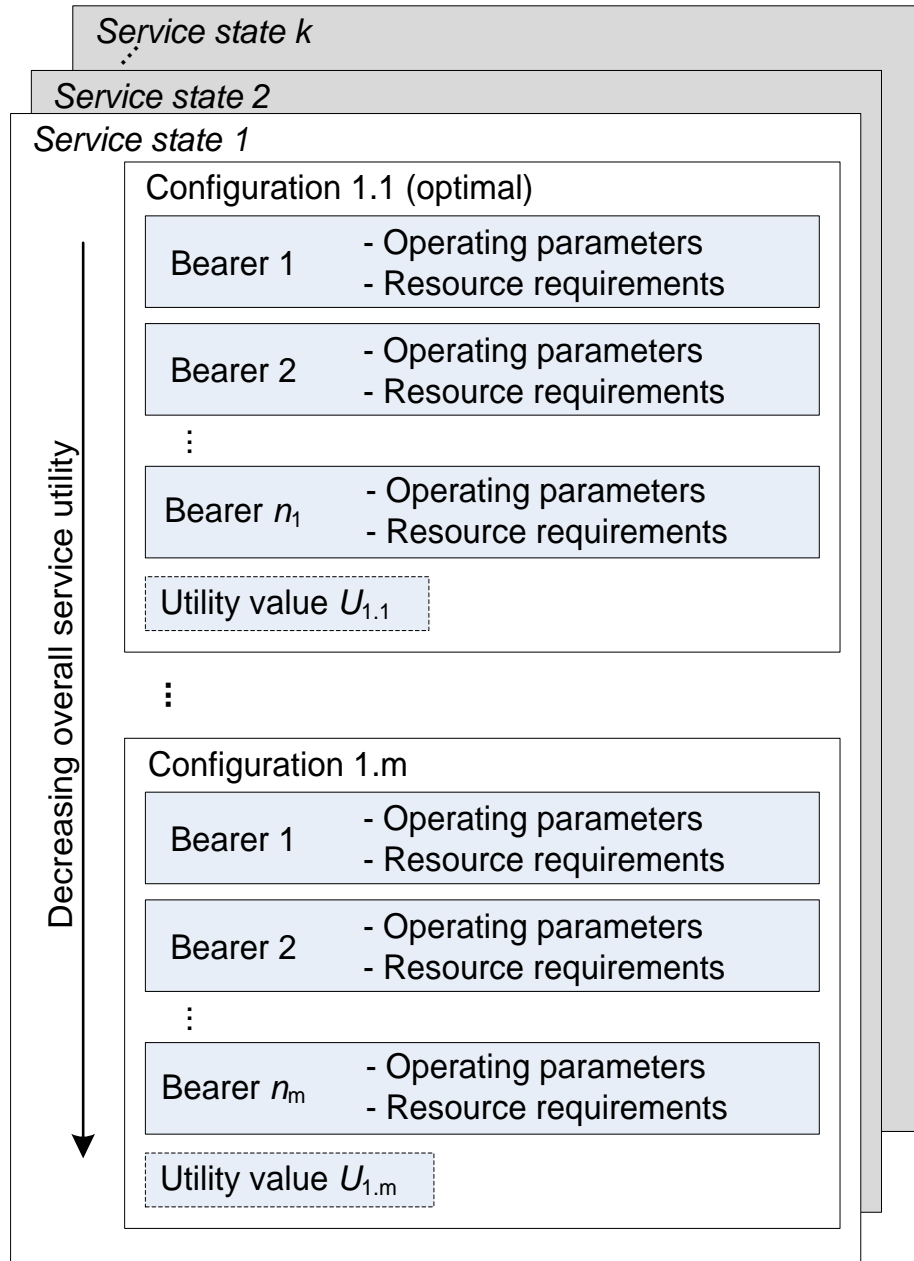
- ◆ For services with several flows, users' preferences regarding flow importance:
  - May vary
  - Should be considered at session initiation time
  
- ◆ Appropriate service description: Media Degradation Path (MDP)
  - A list of service *configurations*
  - Each configuration consists of operating parameters, resource requirements and *utility* value (a numerical indicator of user's satisfaction)



## Mapping between adaptation, resource and utility spaces

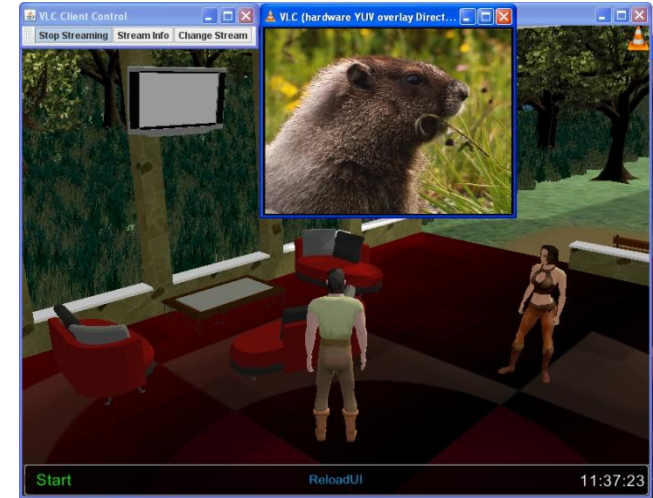
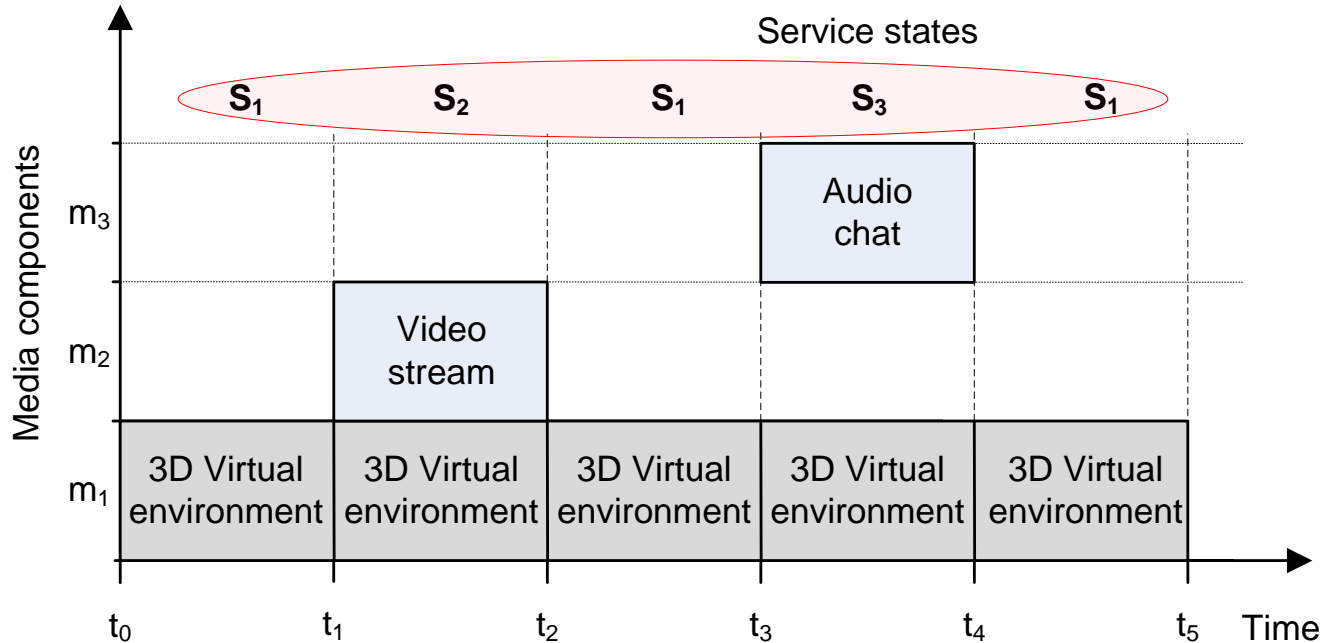
L. Skorin-Kapov and M. Matijasevic, "A data specification model for multimedia QoS negotiation," in *MobiMedia '07: Proc. of the 3rd Int. Conf. on Mobile Multimedia communications*, (Nafpaktos, Greece), pp. 1-7, ICST, 2007.

## Media Degradation Path



# Media degradation path - scheme

# MDP – Service states



An example scenario of a service with three states

- ◆ 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

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

$$\mathbf{b}_{ui} = (\mathbf{b}_{ui1}, \dots, \mathbf{b}_{ui_{z_{ui}}}), \text{ where } \mathbf{b}_{uij} = (b_{uij1}, \dots, b_{uij9})$$

- ◆ 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)

- ◆ Users' utility:

$$F_{ut} = \sum_{u=1}^n \sum_{i=1}^{P_u} \{w_u x_{ui} U_{-n_{ui}}(\mathbf{b}_{ui})\}$$

- ◆ Operator's utility:

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

- ◆ The goal is to maximize the total utility

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

such that bandwidth constraints are fulfilled.

# Resource reallocation: mathematical formulation (3)

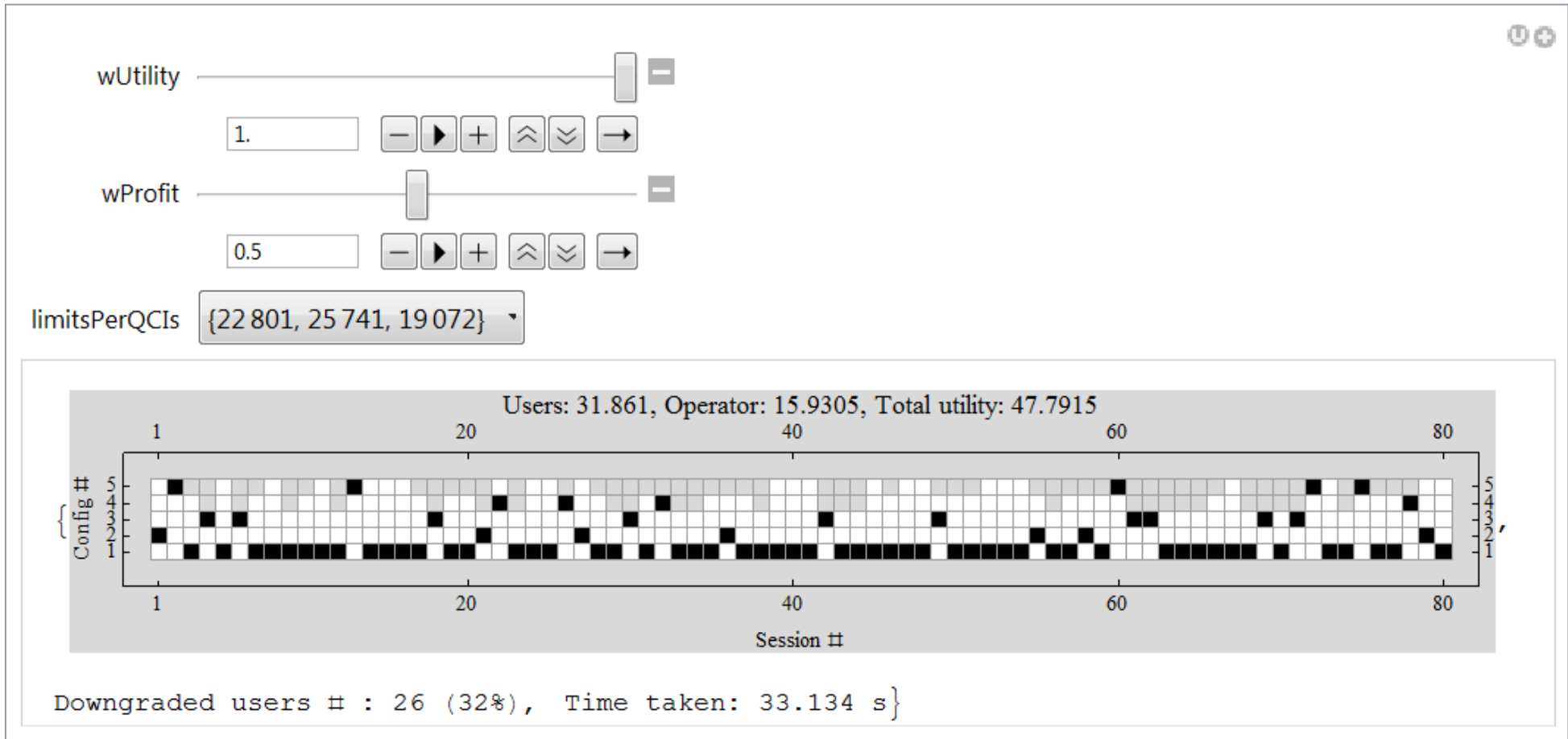
- ◆ The bandwidth constraints:

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

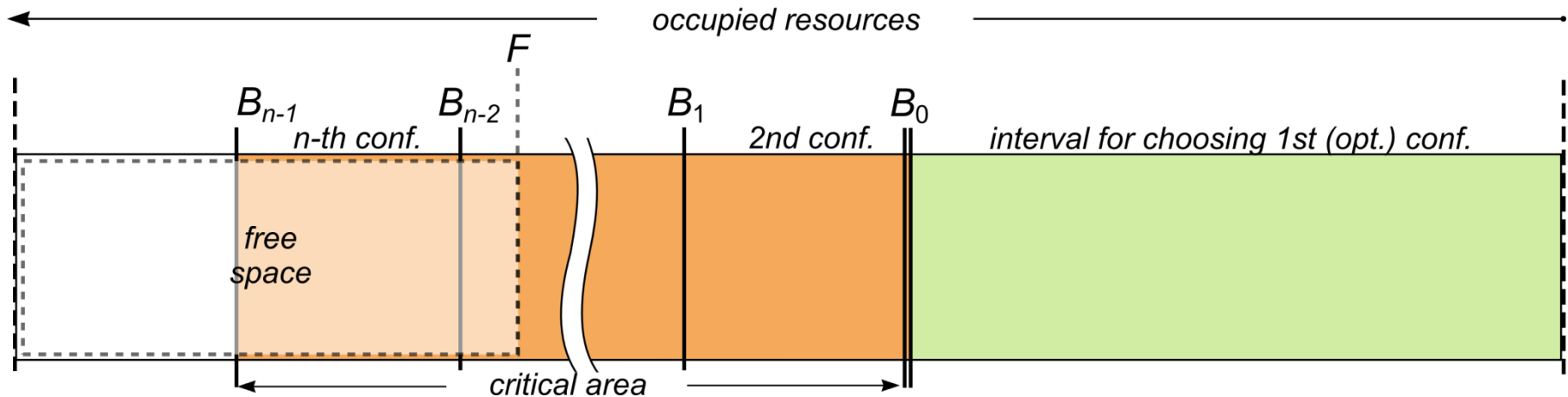
$$\sum_{u=1}^n \sum_{i=1}^{p_u} \sum_{j=h_{ui}+1}^{z_{ui}} x_{ui} b_{uijk} \leq B_{k\_UL}, k = 1, \dots, 9$$

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

- ◆ 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

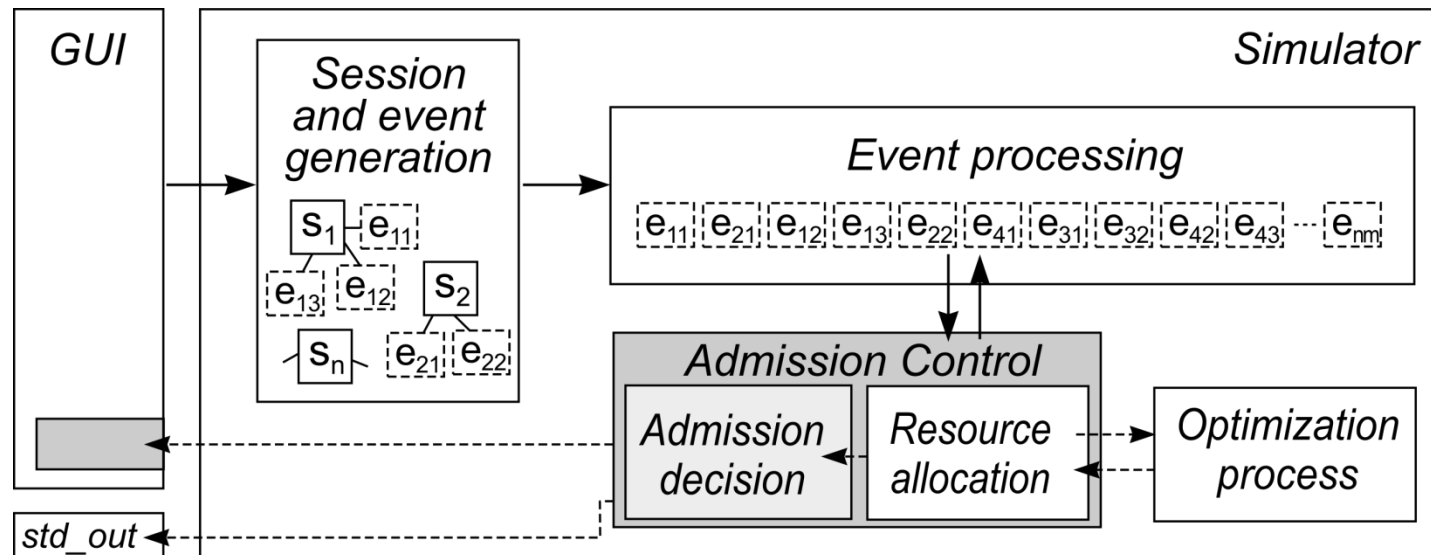


- ◆ In case of decreased resource availability new sessions can be admitted with lower quality configurations from their MDPs, rather than being entirely rejected




- ◆ 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

- ◆ 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**  
File Edit Simulation Help

Active sessions (# = 85, blocked # = 4):

No.	Starting time	Session name
254	263.405	VIDEO_CALL-74
255	263.470	VE-81
256	264.847	VIDEO_CALL-75
257	264.849	VOICE_CALL-48
258	265.088	MMO-32
259	265.754	VIDEO_CALL-76
260	265.937	VIDEO_CALL-77
261	266.523	VE-82
262	266.659	VE-83
263	267.372	VE-84
264	267.841	STREAMING_VIDEO-23
265	268.973	MMO-33
266	270.121	VE-85
267	270.611	STREAMING_VIDEO-24
268	275.968	VE-86
269	278.340	VE-87
270	279.723	VOICE_CALL-49
271	280.712	VIDEO_CALL-78
272	280.803	VIDEO_CALL-79
273	281.219	VIDEO_CALL-80
274	283.339	MMO-34
275	284.765	VE-88
276	286.055	VOICE_CALL-50
277	286.531	VIDEO_CALL-81
278	286.921	VIDEO_CALL-82
279	288.845	VOICE_CALL-51
280	289.543	MMO-35
281	290.236	VOICE_CALL-52
282	293.851	VE-89
283	294.017	VE-90
284	295.030	VE-91

**Selected session**  
VE-85  
User category: BRONZE Service priority: 0.7

State 1 State 2 [Active] State 3

Config 1 Config 2 [Active] Config 3 Config 4 Config 5

QCI 1	QCI 2	QCI 3	QCI 4	QCI 5	QCI 6	QCI 7	QCI 8	QCI 9	Utility	Operator
209	0	3803	0	0	0	0	1311	0	0.8463	0.8651

ARP parameter  
Priority: 6  
Pre-emption capability:   
Pre-emption vulnerability:

Handoff  
Handoff from another cell:

**Optimization parameters**

Priorities  
wUtility: 1.0  
wProfit: 0.5

**QCI usage**

QCI 1: 58%	QCI 2: 53%	QCI 3: 72%
QCI 4: 46%	QCI 5: 33%	QCI 6: 38%
QCI 7: 47%	QCI 8: 80%	QCI 9: 46%

**Active configurations**

240 241 242 243 244 245 246 247 248 249 250 251 252 253 254 255 256 257 258 259 260 261 262 263 264 265 266 267 268 269 270 271 272 273 274 275 276 277 278 279 280 281 282 283 284

Session no.84 is blocked (critical QCI is 9): session ARP (13) > acceptable ARP (12)  
Session no.94 is blocked (critical QCI is 9): session ARP (9) > acceptable ARP (8)  
Session no.96 is blocked (critical QCI is 5): free space in user zone (1400.0) < bandwidth of last configuration (2295)

# 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)

- ◆ 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