IS1304

EUROPEAN COOPERATION
IN SCIENCE AND TECHNOLOGY

Expert Judgement to Enhance
Health Decision Making
Malta, 7-9 Oct. 2015

Recent advances in multiple criteria decision making: applying the aggregation-disaggregation theory in healthcare

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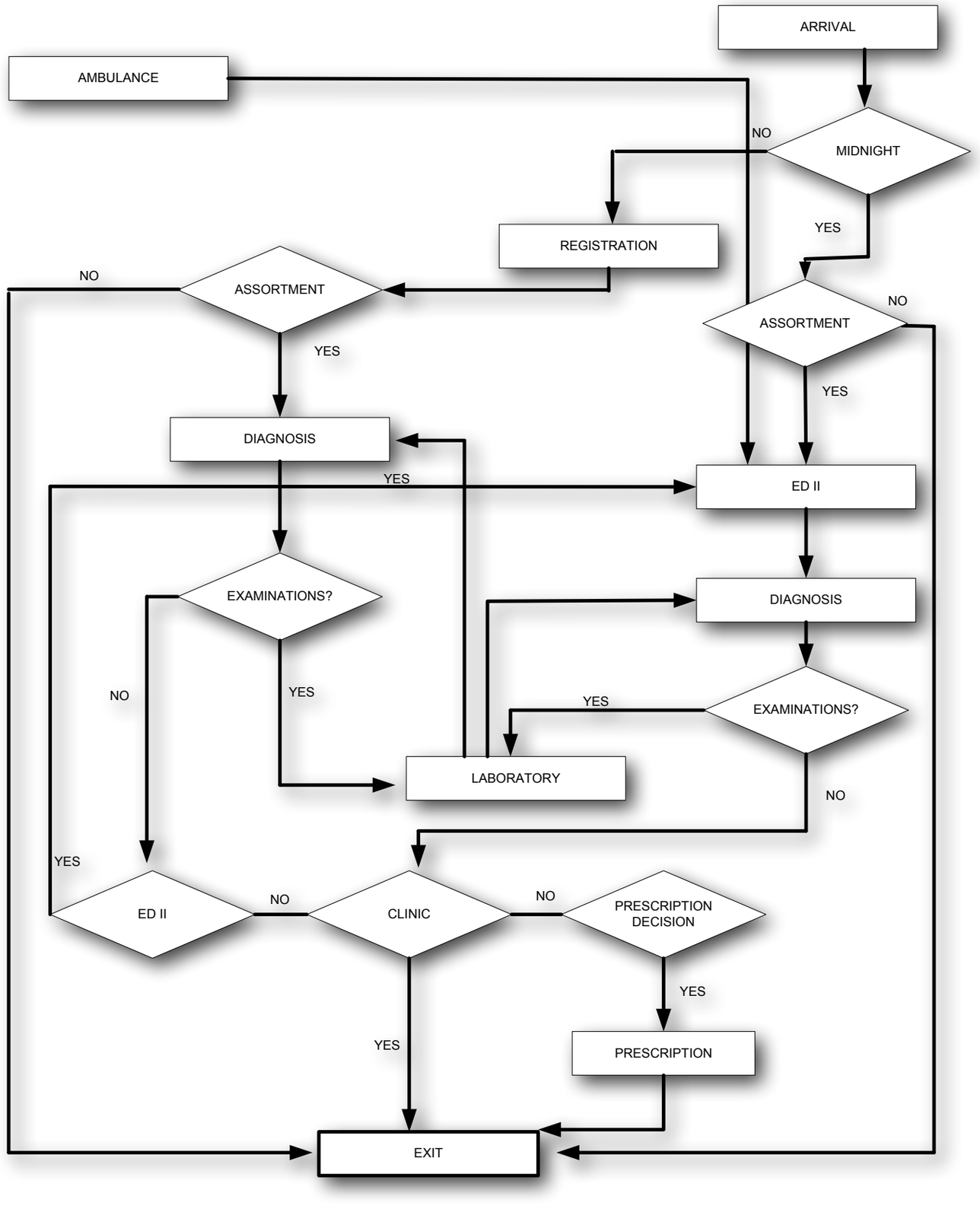
DENYER

Overcrowding effects

- Increased waiting times
- Patients drop out
- Critical treatment delays
- Care quality reduction

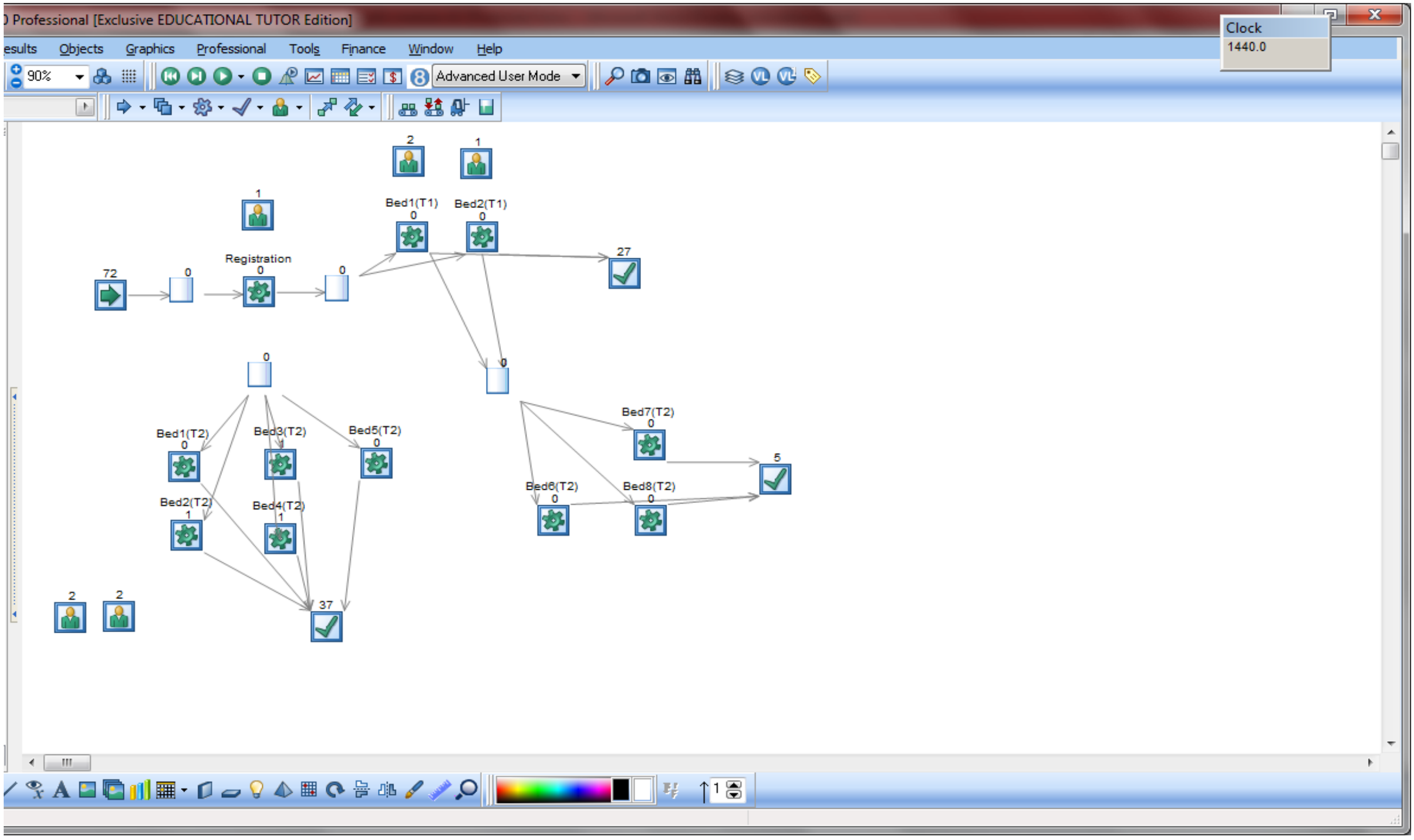
FlowChart of the Emergency Department



Multiple Criteria Perspective

- Waiting time
- Length of stay
- Doctors' working load
- Nurses' working load
- Beds Utilization

Simulation (SIMU8 layout)



Typical input

	Waiting Time	Doctors' Load	Utilization
Scenario 1	50 min	70%	80%
Scenario 2	70 min	64%	71%
Scenario 3	45 min	86%	92%

Then the expert comes

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Scenario 1	50 min	70%	80%
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Then the expert comes

	Waiting Time	Doctors' Load	Utilization	Ranking
Scenario 1	50 min	70%	80%	**1**
Scenario 2	70 min	64%	71%	**2**
Scenario 3	45 min	86%	92%	**2**

What we expect

- Assess the DM's preference model
- Measure the consistency between the assessed preference model and the a priori preferences of the DM,
- Assess values (values, weights, utilities, ...), and
- Evaluate potential actions (extrapolation output)

UTA principles (1)

$$\begin{cases} u\left[\mathbf{g}\left(a\right)\right] > u\left[\mathbf{g}\left(b\right)\right] \Leftrightarrow a \succ b & \text{(preference)} \\ u\left[\mathbf{g}\left(a\right)\right] = u\left[\mathbf{g}\left(b\right)\right] \Leftrightarrow a \sim b & \text{(indifference)} \end{cases}$$

$$u\left(\mathbf{g}\left(a\right)\right) = \sum_{i=1}^{n} u_i\left[g_i\left(a\right)\right] - \sigma^+\left(a\right) + \sigma^-\left(a\right)$$

$\Delta\left(a_k, a_{k+1}\right) = u\left[\mathbf{g}\left(a_k\right)\right] - \sigma^+\left(a_k\right) + \sigma^-\left(a_k\right) - u\left[\mathbf{g}\left(a_{k+1}\right)\right] - \sigma^+\left(a_{k+1}\right) + \sigma^-\left(a_{k+1}\right)$

UTA principles (2)

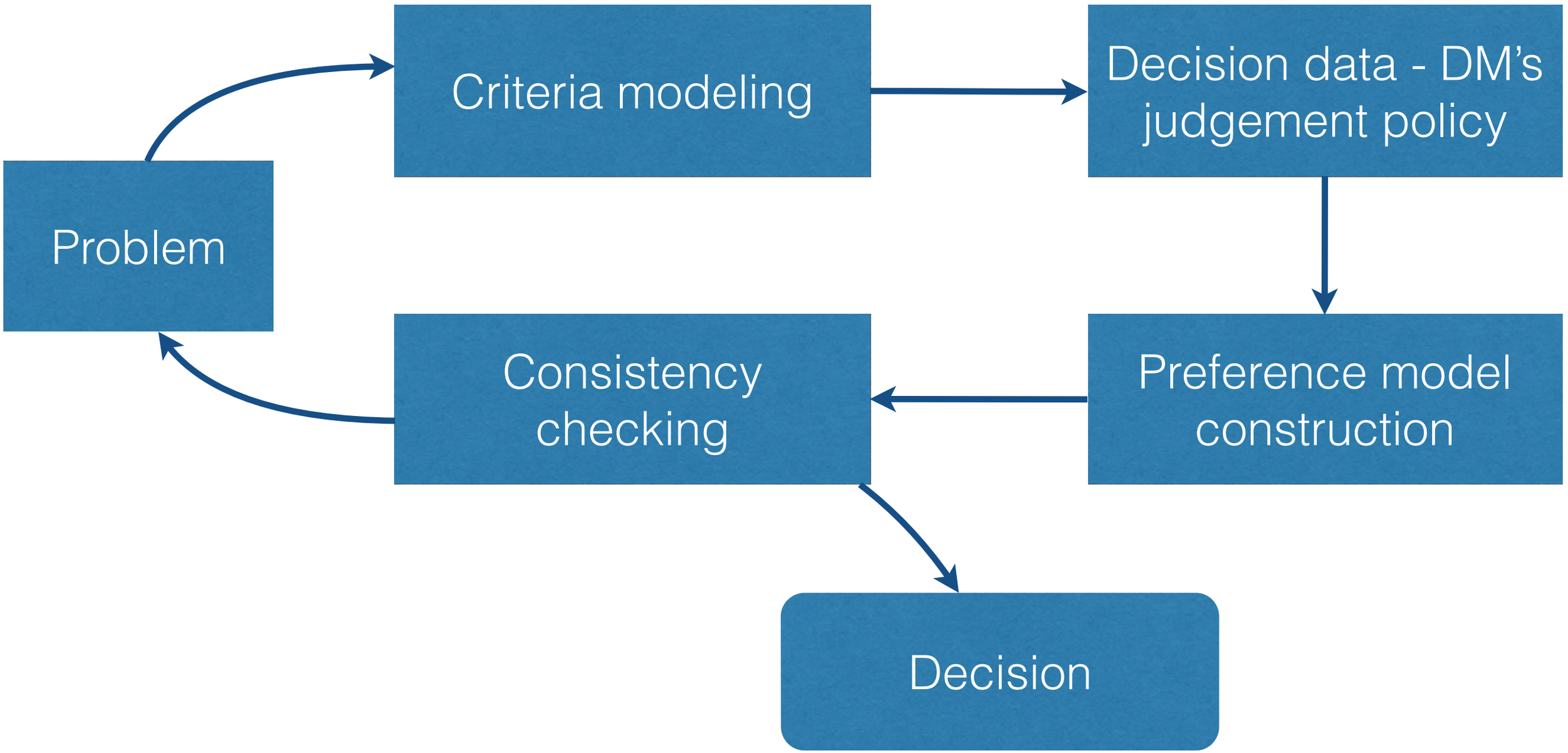
$$\min z = \sum_{k=1}^{m} \left[\sigma^{+}(a_k) + \sigma^{-}(a_k) \right]$$

s.t.

$$\left\{ \begin{array}{ll} \Delta(a_k, a_{k+1}) \geq \delta & \text{if } \alpha_\kappa \succ a_{k+1} \\ \Delta(a_k, a_{k+1}) = 0 & \text{if } \alpha_\kappa \sim a_{k+1} \end{array} \right\}, \forall k$$

$$\vdots$$

The disaggregation-aggregation approach



What’s the catch?

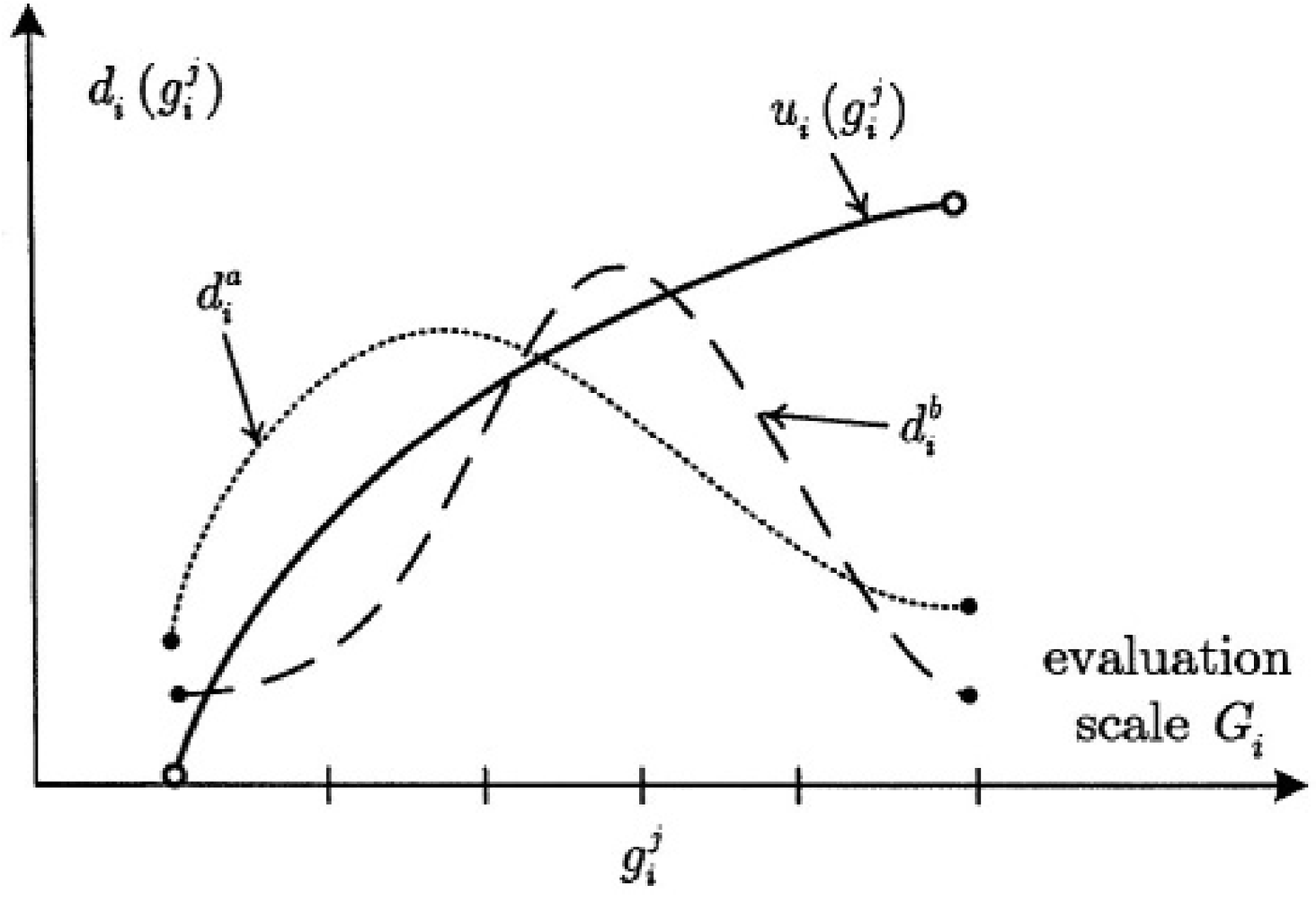
	Waiting Time	Doctors’ Load	Utilization	Ranking
Scenario 1	50 min	70%	80%	**1**
Scenario 2	70 min	64%	71%	**2**
Scenario 3	45 min	86%	92%	**2**

What’s the catch?

	Waiting Time	Doctors’ Load	Utilization	Ranking
Scenario 1	50 min	70%	80%	**1**
Scenario 2	70 min	64%	71%	**2**
Scenario 3	45 min	86%	92%	**2**

Stochastic UTA

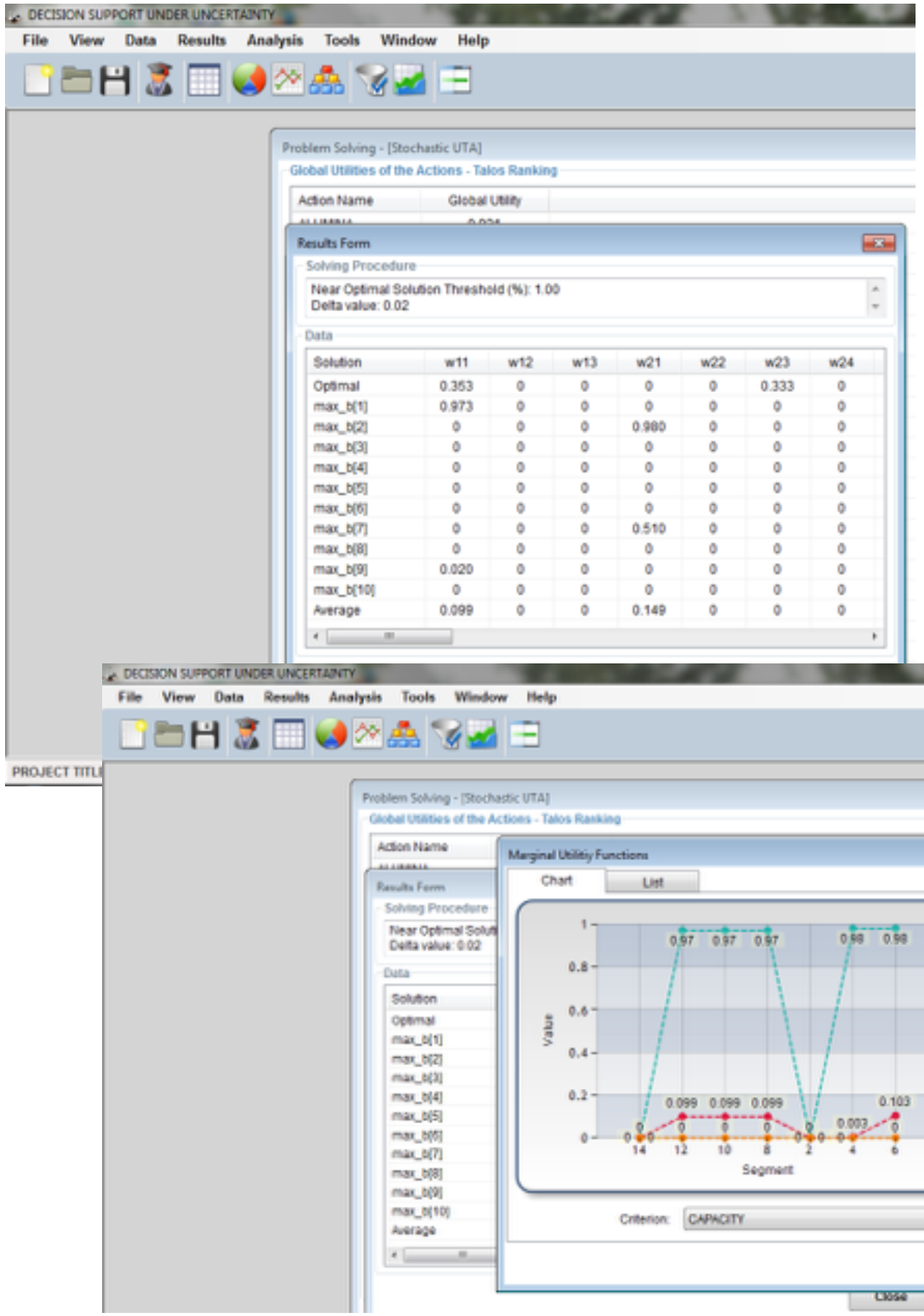
$$u\left(\mathbf{d}^{a}\right)=\sum_{i=1}^{n}\sum_{j=1}^{\alpha_{i}}d_{i}^{a}\left(g_{i}^{j}\right)u_{i}\left(g_{i}^{j}\right)$$

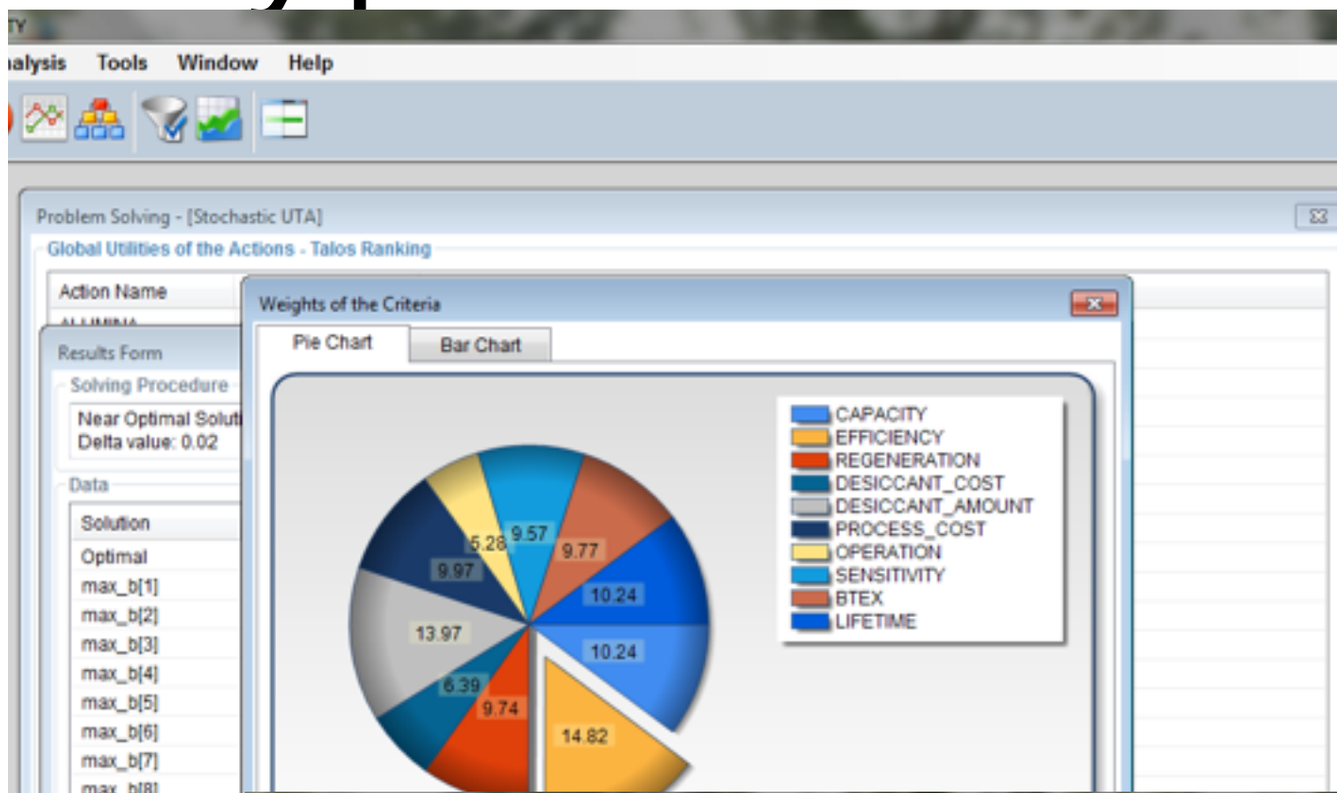


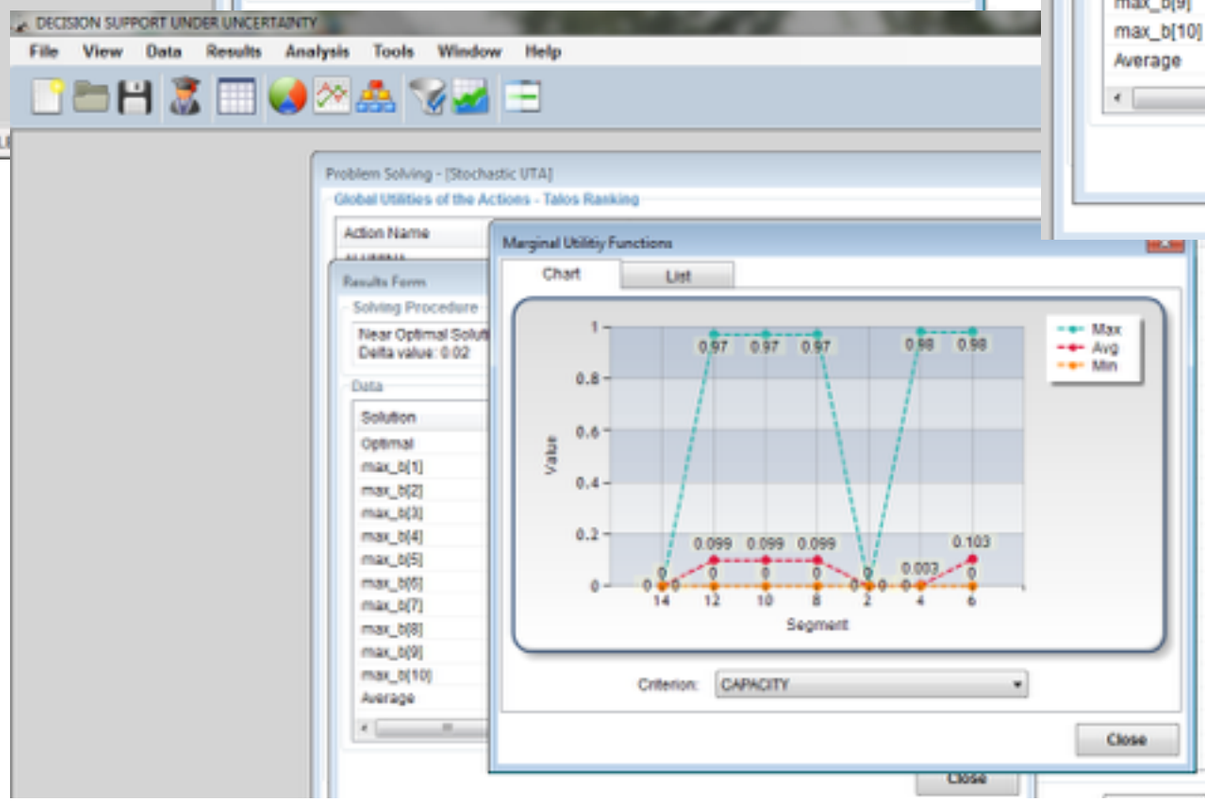
New typical input

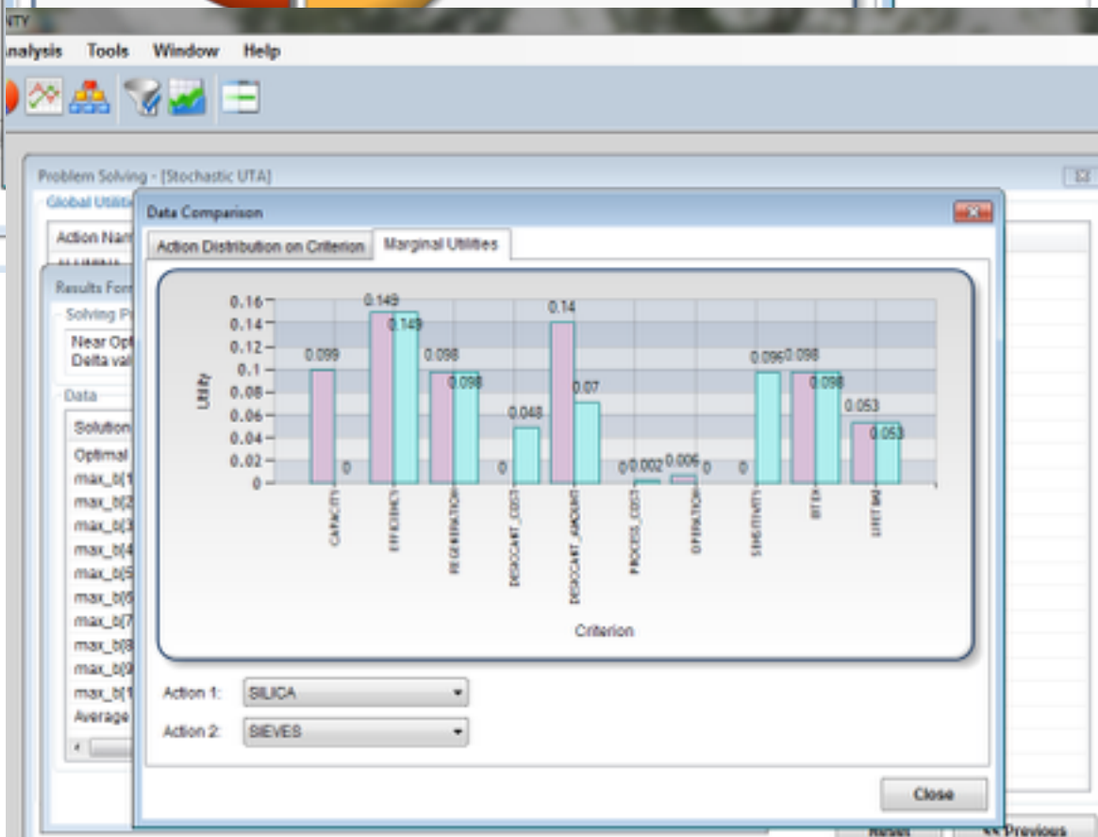
	Waiting Time (min)				Length of Stay (min)			Doctors Working Load (%)			Nurses Working Load (%)			Beds Usage (%)			
	0-20	20-40	40-60	60-80	0-100	100-200	200-300	0-33	33-66	66-100	0-33	33-66	66-100	0-25	25-50	50-75	75-100
	10	30	50	70	50	150	250	16,5	50	83,5	16,5	50	83,5	12,5	37,5	62,5	87,5
Scenario 1	96.9	3.1	0.0	0.0	35.0	62.3	2.8	28.4	71.6	0.0	0	100	0	37.7	29.6	32.7	0.0
Scenario 2	97.2	2.8	0	0	66.1	29.8	4.1	38.5	61.5	0	0	100	0	40	52.6	7.4	0
Scenario 3	53.7	42.9	3.4	0.1	33.3	61.8	4.9	37.5	13.8	48.7	0	100	0	30.7	30.3	39.1	0
Scenario 4	86.3	13.4	0.4	0	35.9	63.9	0.2	28.4	22	49.6	0	98.9	1.1	39.3	36.32	24.4	0
Scenario 5	94.1	5.8	0.1	0	93.4	6.6	0	50	50	0	50	50	0	55.5	26.2	18.3	0
Scenario 6	93.4	6.5	0.1	0	89.1	10.9	0	48	8.6	43.4	50	50	0	60	27.6	13.3	0
Scenario 7	71.6	25.7	2.4	0.2	66.7	33.3	0	28.5	23.1	48.5	50	49.6	0.4	59.9	20.2	19.9	0

A prototype


DECISION SUPPORT UNDER UNCERTAINTY
File View Data Results Analysis Tools Window Help
Problem Solving - [Stochastic UTA]
Global Utilities of the Actions - Talos Ranking
Action Name
Global Utility
Results Form
Solving Procedure
Near Optimal Solution Threshold (%): 1.00
Delta value: 0.02
Data
Solution w11 w12 w13 w21 w22 w23 w24
Optimal 0.353 0 0 0 0 0.333 0
max_b[1] 0.973 0 0 0 0 0 0
max_b[2] 0 0 0 0.980 0 0 0
max_b[3] 0 0 0 0 0 0 0
max_b[4] 0 0 0 0 0 0 0
max_b[5] 0 0 0 0 0 0 0
max_b[6] 0 0 0 0 0 0 0
max_b[7] 0 0 0 0.510 0 0 0
max_b[8] 0 0 0 0 0 0 0
max_b[9] 0.020 0 0 0 0 0 0
max_b[10] 0 0 0 0 0 0 0
Average 0.099 0 0 0.149 0 0 0


Problem Solving - [Stochastic UTA]
Global Utilities of the Actions - Talos Ranking
Action Name
Results Form
Solving Procedure
Near Optimal Solut
Delta value: 0.02
Data
Solution
Optimal
max_b[1]
max_b[2]
max_b[3]
max_b[4]
max_b[5]
max_b[6]
max_b[7]
max_b[8]
max_b[9]
max_b[10]
Average
Weights of the Criteria
Pie Chart
Bar Chart
CAPACITY
EFFICIENCY
REGENERATION
DESICCANT_COST
DESICCANT_AMOUNT
PROCESS_COST
OPERATION
SENSITIVITY
BTEX
LIFETIME
9.57
9.77
5.28
9.97
10.24
13.97
10.24
6.39
9.74
14.82

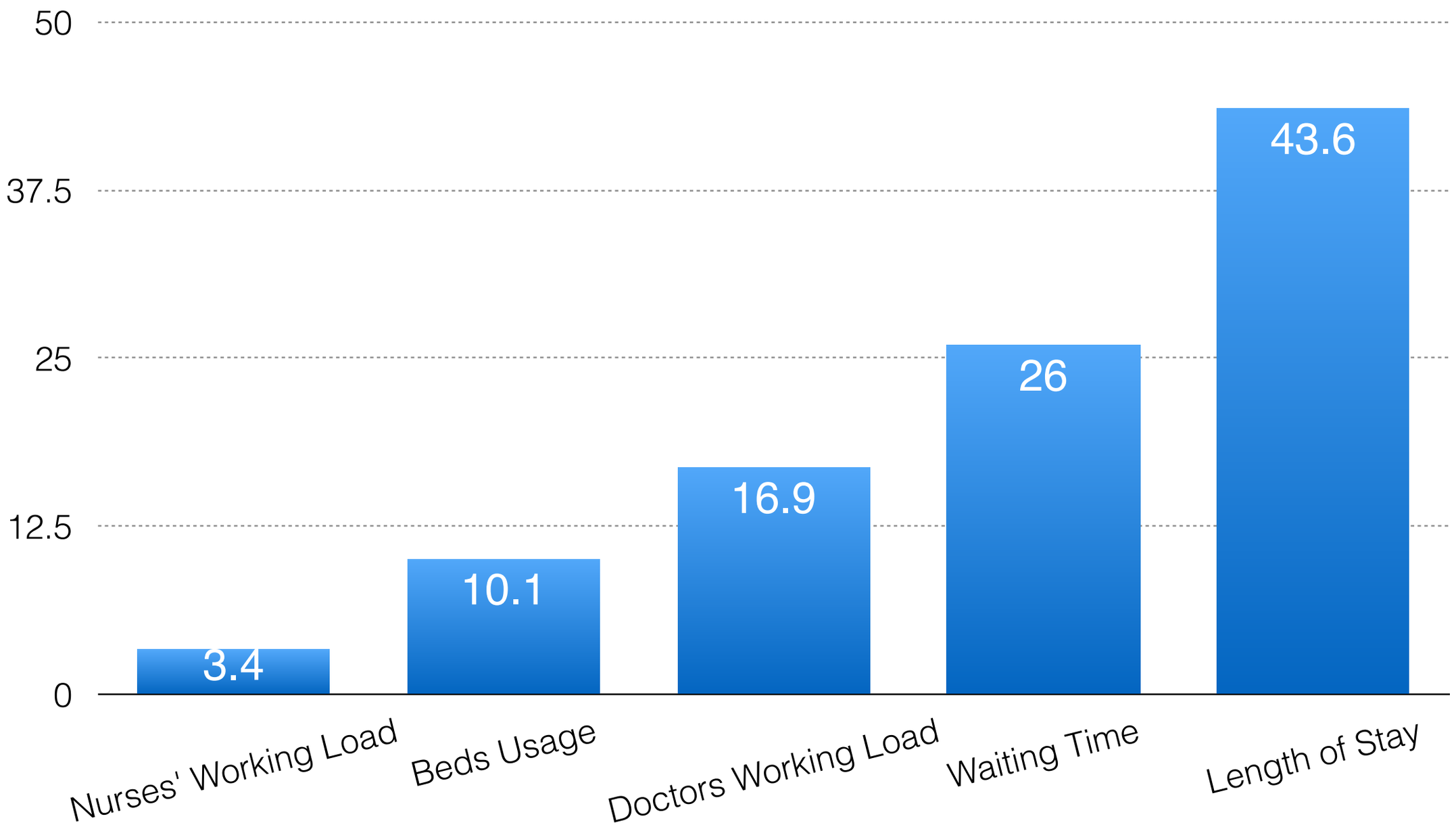

DECISION SUPPORT UNDER UNCERTAINTY
File View Data Results Analysis Tools Window Help
PROJECT TITLE
Problem Solving - [Stochastic UTA]
Global Utilities of the Actions - Talos Ranking
Action Name
Marginal Utility Functions
Chart
List
Max
Avg
Min
Value
Segment
Criterion:
CAPACITY
Close


Problem Solving - [Stochastic UTA]
Data Comparison
Action Distribution on Criterion
Marginal Utilities
Utility
Criterion
Action 1:
SILICA
Action 2:
SIEVES
Close

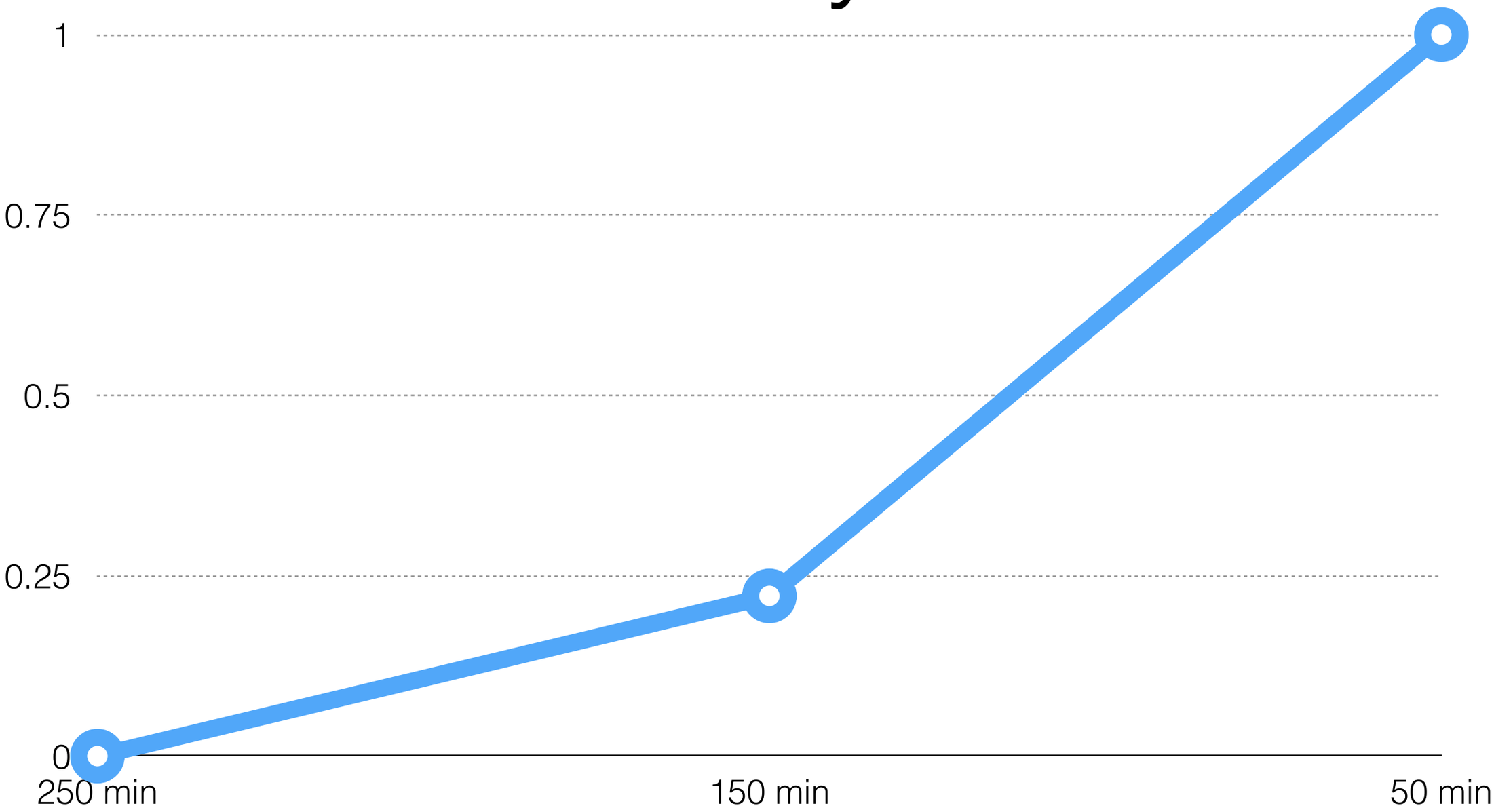
Scenaria Evaluation

Scenarios	DM	UTA*	Utility
Scenario 1	7	7	0.486
Scenario 2	6	6	0.506
Scenario 3	5	5	0.526
Scenario 4	4	4	0.557
Scenario 5	2	2	0.673
Scenario 6	1	1	0.727
Scenario 7	3	3	0.651

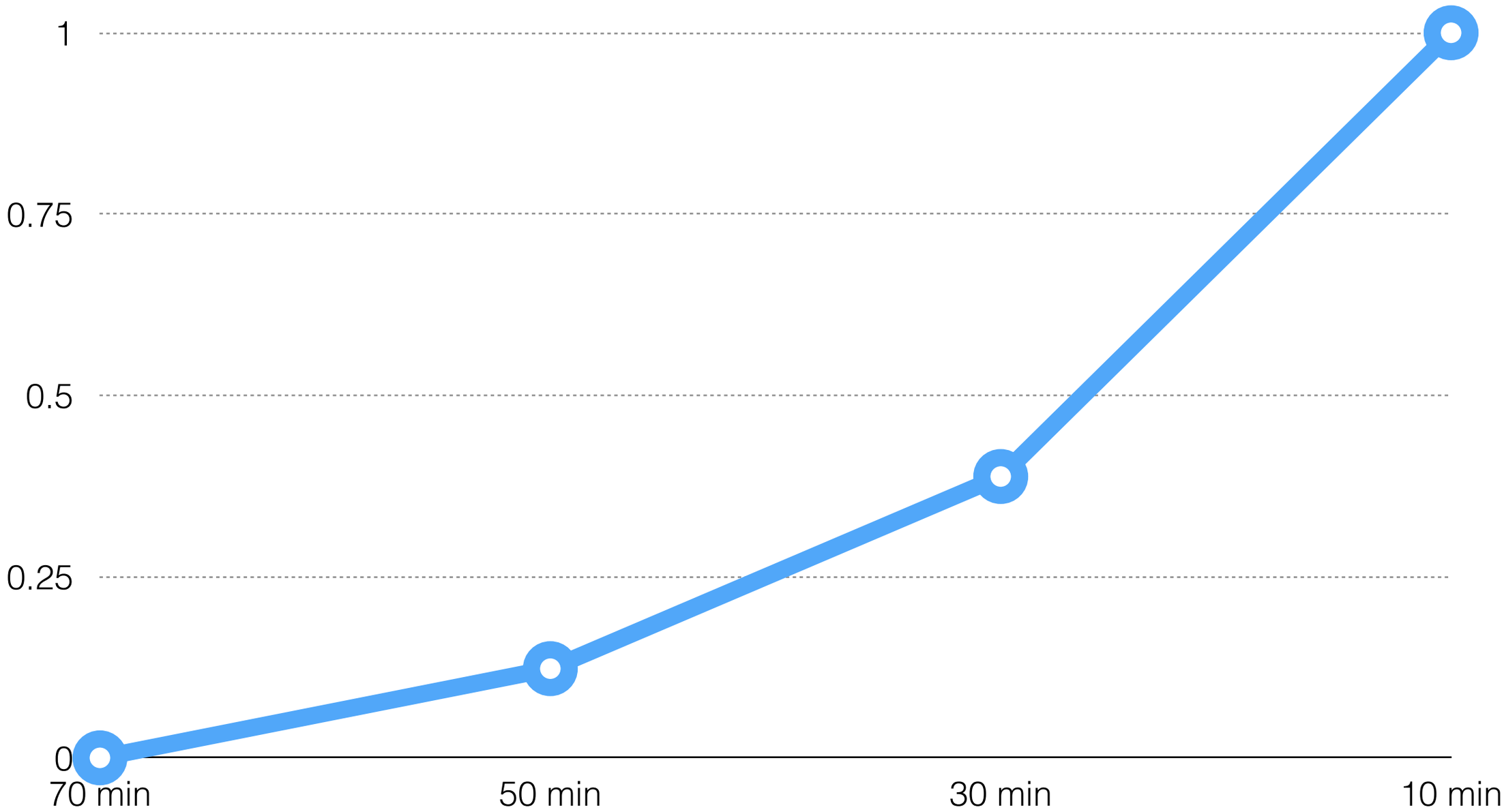
Criteria Weights



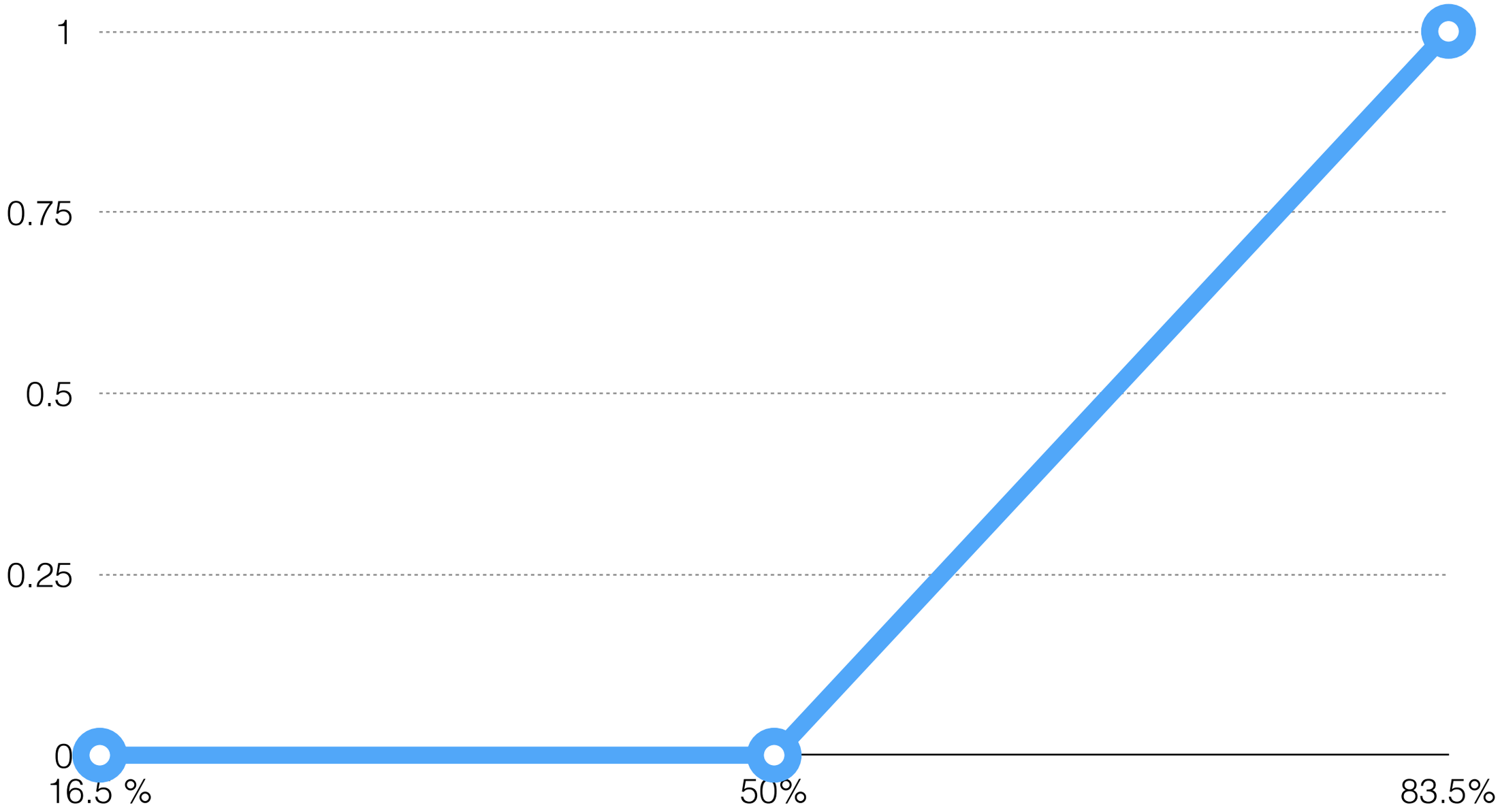
Utility Function: Length of Stay



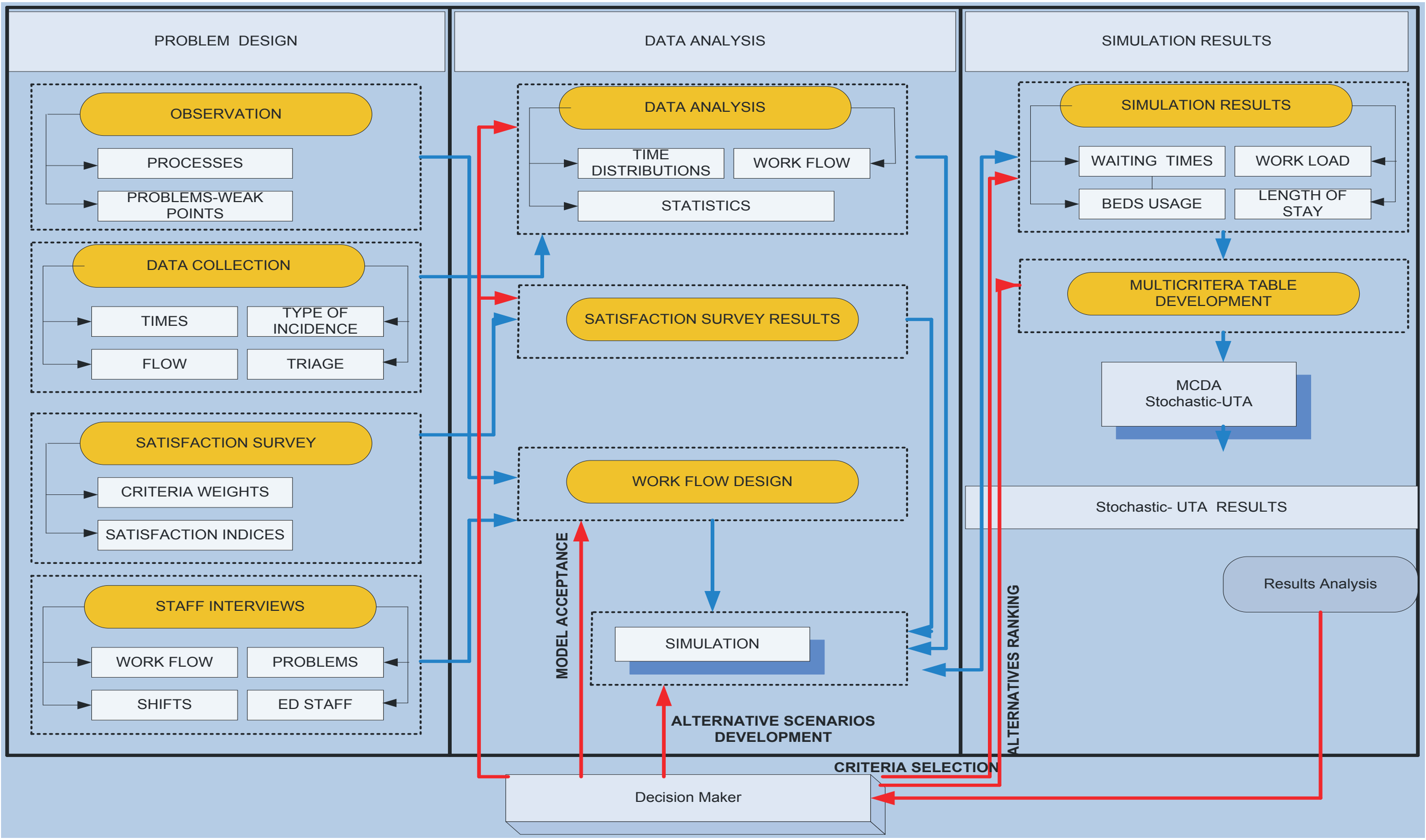
Utility Function: Waiting Time



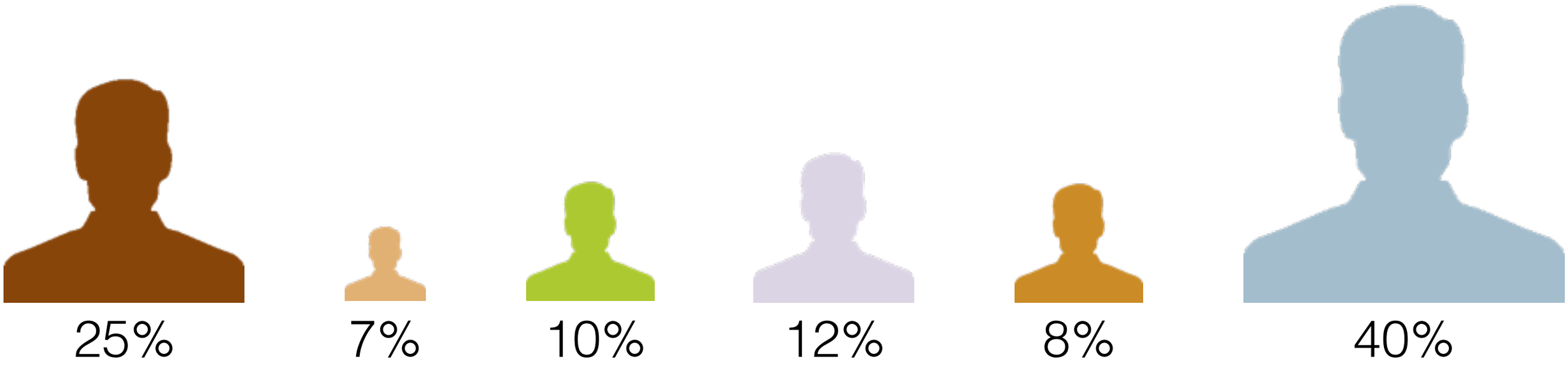
Utility Function: Doctors' Load



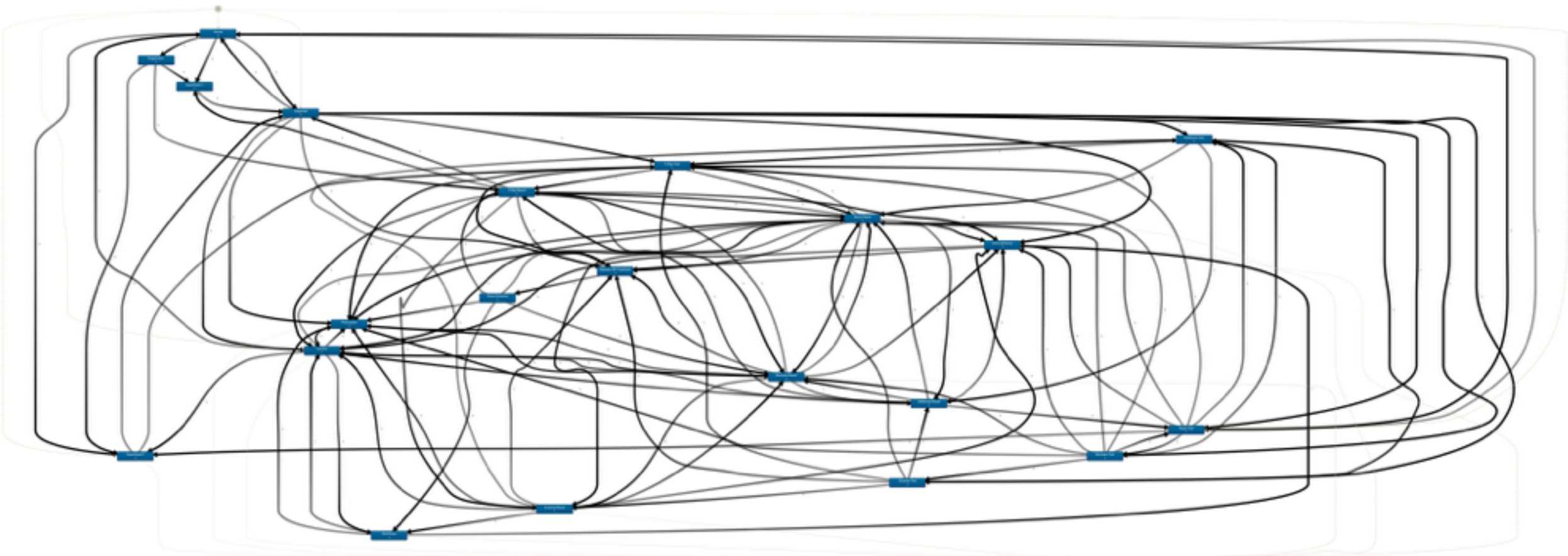
MED-UTA: An integrated methodology



Future Works - Multiple Experts



Future Work - Process Mining



119
Arrival
119
2
Registration
2
114
2
1
Assortment 2
119
117
Diagnosis
119
13
46
35
X.Ray Test
25
Blood Test
51
24
41
X.Ray Result
25
Biochem.Test
45
7
4
Prescription
42
Additional Test
5
41
28
3
Exit ER
119
Additional Result
5
4
17
3
Blood Result
51
112
22
41
Biochem.Result
45
11
Clinic Entrance
22

21
Arrival
21
21
Assortment 2
21
21
Diagnosis
21
21
Blood Test
21
21
Biochem.Test
21
21
Enzyma.Test
21
1
11
Additional Test
2
1
X.Ray Test
12
10
X.Ray Result
12
10
Blood Result
21
11
Biochem.Result
21
13
8
1
3
Enzyma.Result
21
Additional Result
2
Prescription
3
8
1
1
Clinic Entrance
10
3
10
Exit ER
21
20

97
Arrival
97
92
Registration
92
91
Assortment 1
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97
Diagnosis
97
36
Blood Test
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34
Biochem.Test
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17
10
11
25
Enzyma Test
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Blood Result
38
2
1
X.Ray Test
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Decision.ER Treatment
9
16
X.Ray Result
21
9
28
Room.Entrance
9
10
Prescription
57
57
15
Exit ER
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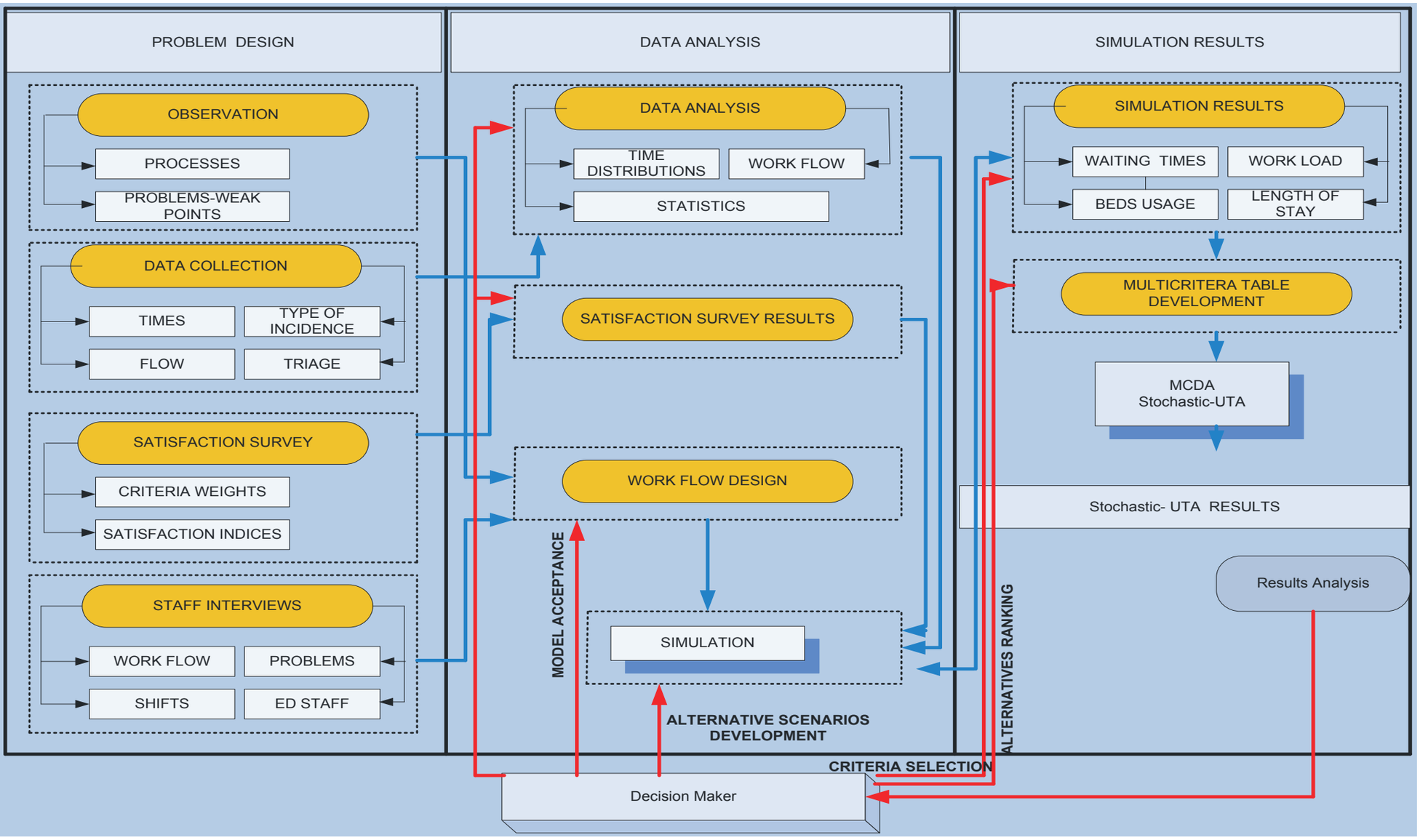
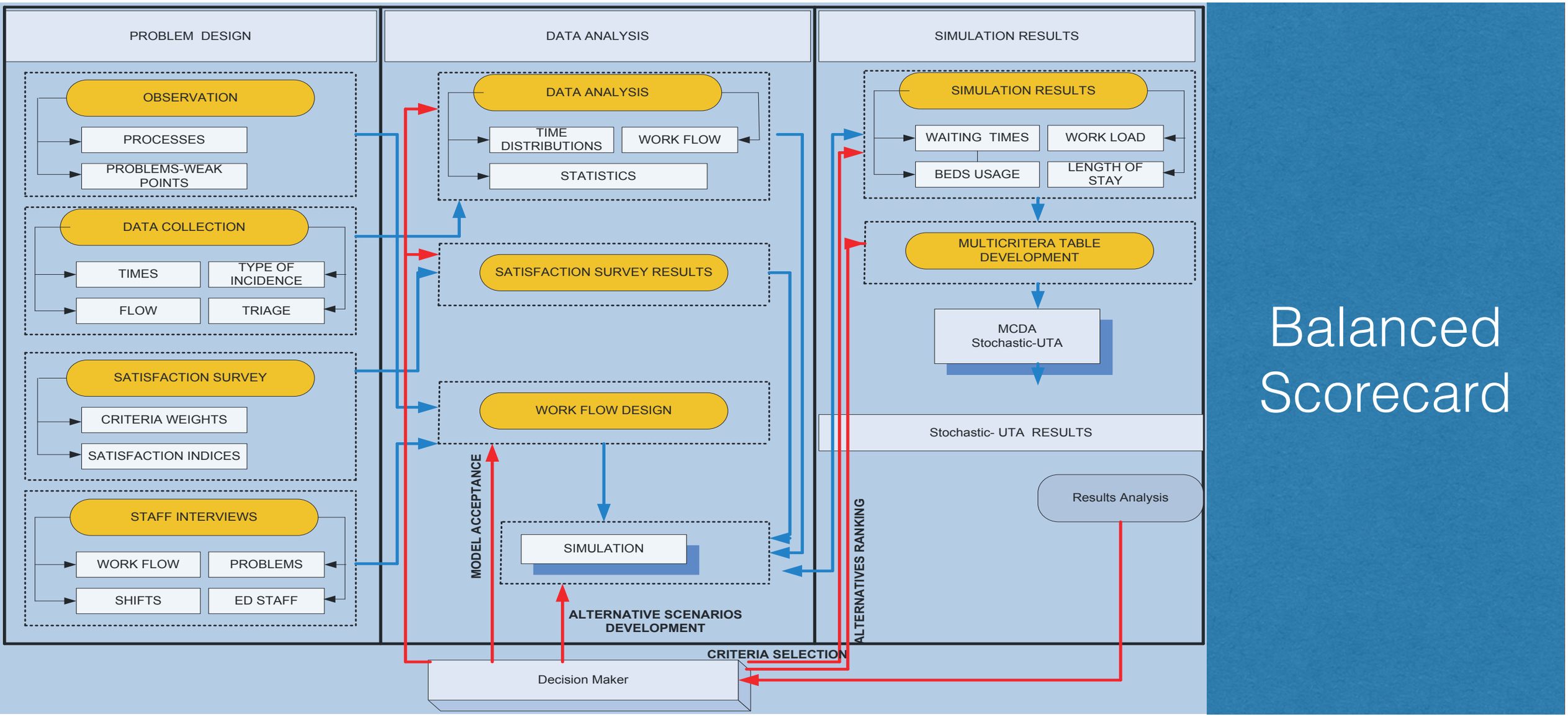
Biochem.Result
35
11
6
94
Enzyma.Result
13
4
Exit Room
9

Future Work - Balanced Scorecard



Future Work - Balanced Scorecard



Thank you!