Healthcare Technology Engineering

WARWICK

AHP for user need elicitation: method and tools

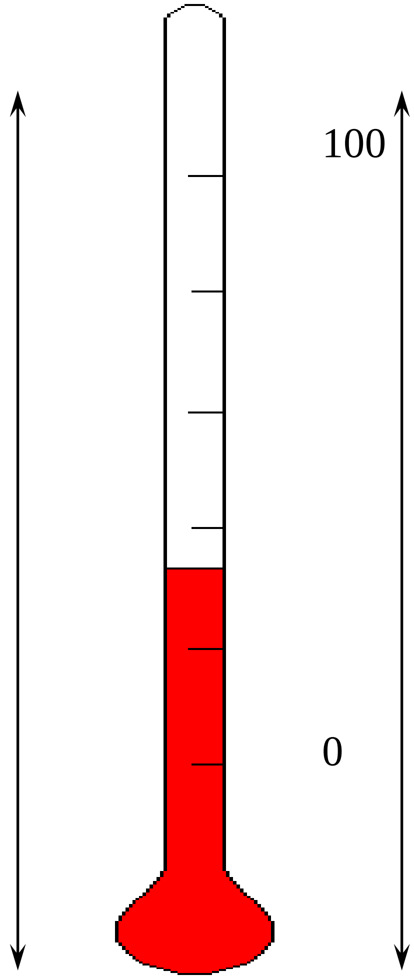
Dr Leandro Pecchia

Relative Nature of Absolute Scales

Good for preserving food

Bad for preserving food

Good for preserving food



Temperature

Bad for comfort

Good for comfort

Bad for comfort

Basic Decision Problem

Criteria: Low Cost > Operating Cost > Style

Car:	A	B	B
	V	V	V
Alternatives:	B	A	A

Suppose the criteria are preferred in the order shown and the cars are preferred as shown for each criterion. Which car should be chosen? It is desirable to know the strengths of preferences for tradeoffs.

Introduction

Problem description

- In healthcare the personnel are committed to follow only the **best available evidence**
- Despite the hierarchy of evidence, the complexities of medical knowledge require a spectrum of qualitative and quantitative information
- The adoption of s*cientific quantitative methods to quantify* qualitative information is crucial

Introduction

AHP contribution

- The Analytic Hierarchy Process (AHP) is a multi-dimensional, multi-level and multifactorial decision-making method based on the idea that it is possible to prioritize elements by:
  - grouping them into meaningful categories and sub-categories;
  - performing pairwise comparisons;
  - defining a coherent framework of quantitative and qualitative knowledge;
  - measuring intangible domains.
- This hierarchical approach allows:
  - the construction of a consistent framework for step-by-step decision-making,
  - breaking a complex problem into many small less-complex ones that decision-makers can more easily deal with.
- Let's go into the method with an exempla…

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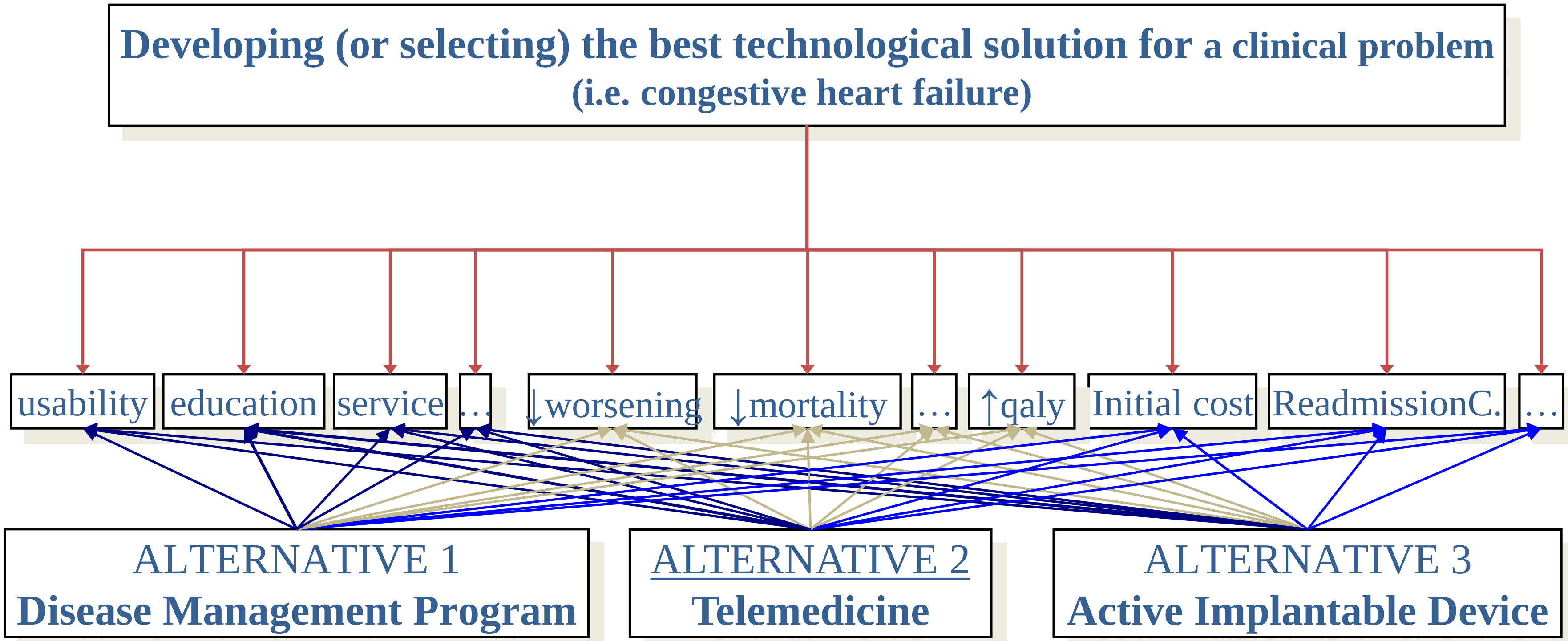
Need Analysis: Identification

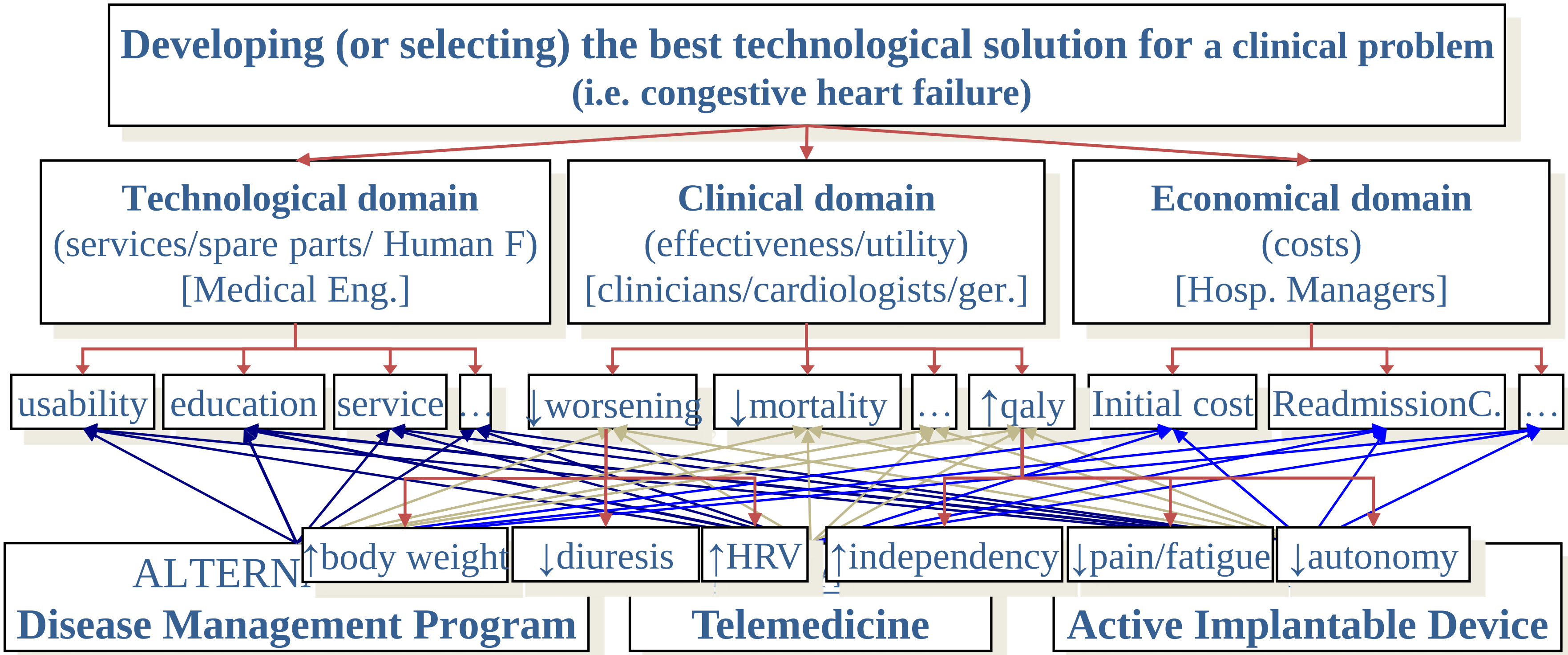
- Identify the best healthcare technology to solve a given problem:
  - The first step is to identify all the needs:



- Now you will need to measure:
  - How important is each need (outcome/output/costs..) compared to the others?
  - Which alternative satisfy better each need?
- Would it be easy to compare such different needs?

Need analysis: classification

- Identify the best healthcare technology to solve a given problem:
  - The first step is to identify all the needs:



- Now you can measure:
  - How important is each **clinical need** compared to the others: meta-analysis?
  - How important is each **economical constrain** compared to the others: health-economy?
  - Which alternative satisfy better each need: clinical engineering?

Need Analysis: prioritization

NEEDS' INDIVIDUATION

EXPERTS

TREE OF NEEDS

QUESTIONNAIRES

Numerical values	
Much more	(5)
More important	(3)
Equally important	(1)
Less important	(1/3)
Much less important	(1/5)

According to your experience, how important is each need on the left compared with each one on the right?

Need 1 (↓ mortality)	Is:	*much more*	*more*	*equally*	~~*less*~~	*much less*	important hen	*Need 2 (↓ Pz. worsening)*
Need 2 (↓ Pz. worsening)	is:	*much more*	*more*	~~*equally*~~	*less*	*much less*	important hen	*Need 3 (↑ QALY)*
Need 3 (↑ QALY)	is :	~~*much more*~~	*more*	*equally*	*less*	*much less*	important hen	*Need 1 (↓ mortality)*

RELATIVE IMPORTANCE OF NEEDS

RELATIVE IMPORTANCE OF NEEDS' CATEGORIES

ALTERNATIVES' PERFORMANCE ASSESSMENT

ALTERNATIVES' PRIORITIZATION

N1 > N2 & N2 > N3 =>

- **N1 >> N3**
- **N1 > N3**
- ~~**N1 < N3**~~

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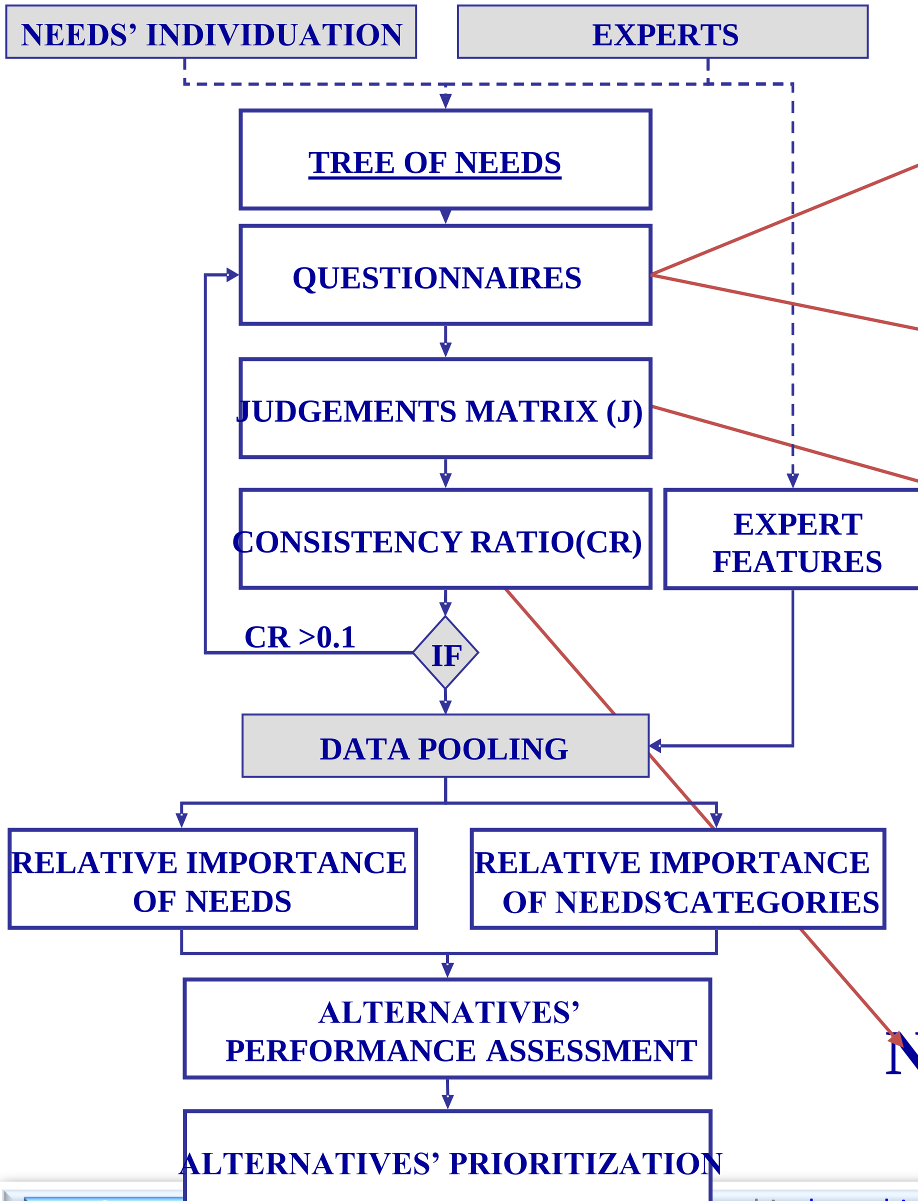
Need Analysis: prioritization



Numerical values	
Much more	(5)
More important	(3)
Equally important	(1)
Less important	(1/3)
Much less important	(1/5)

According to your experience, how important is each need on the left compared with each one on the right?

Need 1 (↓ mortality)	Is:	much more	more	equally	~~less~~	much less	important hen	**Need 2 (↓ Pz. worsening)**
Need 2 (↓ Pz. worsening)	is:	much more	more	~~equally~~	less	much less	important hen	**Need 3 (↑ QALY)**
Need 3 (↑ QALY)	is :	~~much more~~	more	equally	less	much less	important hen	**Need 1 (↓ mortality)**

	N1	N2	N3
N1	1	I_{21}	I_{31}
N2	$I_{12}=1/I_{21}$	1	I_{32}
N3	$I_{13}=1/I_{31}$	$I_{23}=1/I_{32}$	1

Eigenvector (priorities)

Eigen value (coherence)

N1 > N2 & N2 > N3 =>

- **N1 >> N3**
- **N1 > N3**
- ~~**N1 < N3**~~

The Local Needs

Developing (or selecting) the best technological solution for a clinical problem (i.e. congestive heart failure)

Technological domain
(services/spare parts/ Human F)
[Medical Eng.]
- usability
- education
- service

Clinical domain
(effectiveness/utility)
[clinicians/cardiologists/ger.]

Cat=2 SCW^1 — Cat=2 SCW^2 — Cat=2 SCW^3

- ↓worsening
- ↓mortality
- ↑qaly

Economical domain
(costs)
[Hosp. Managers]
- Initial cost
- ReadmissionC.

According to your experience, how important is each need on the left compared with each one on the right?

Need 1* (↓ *mortality)	Is:	*much more*	*more*	*equally*	~~*less*~~	*much less*	important hen	***Need 2* (↓ *Pz. worsening)***
Need 2* (↓ *Pz. worsening)	is:	*much more*	*more*	~~*equally*~~	*less*	*much less*	important hen	***Need 3* (↑ *QALY)***
Need 3* (↑ *QALY)	is :	~~*much more*~~	*more*	*equally*	*less*	*much less*	important hen	***Need 1* (↓ *mortality)***

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The Local Needs

Developing (or selecting) the best technological solution for a clinical problem (i.e. congestive heart failure)

Technological domain
(services/spare parts/ Human F)
[Medical Eng.]

- Cat=1 SCW^1 → usability
- Cat=1 SCW^2 → education
- Cat=1 SCW^3 → service

Clinical domain
(effectiveness/utility)
[clinicians/cardiologists/ger.]

- Cat=2 SCW^1 → ↓worsening
- Cat=2 SCW^2 → ↓mortality
- Cat=2 SCW^3 → ↑qaly

Economical domain
(costs)
[Hosp. Managers]

- Cat=3 SCW^1 → Initial cost
- Cat=3 SCW^2 → ReadmissionC.

According to your experience, how important is each need on the left compared with each one on the right?

usability	Is:	*much more*	*more*	*equally*	~~*less*~~	~~*much less*~~	important hen	education
education	is:	*much more*	~~*more*~~	~~*equally*~~	*less*	*much less*	important hen	service
service	is :	~~*much more*~~	*more*	*equally*	~~*less*~~	*much less*	important hen	usability

The Local Needs

Developing (or selecting) the best technological solution for a clinical problem (i.e. congestive heart failure)

$CW^{Cat=1}$ $CW^{Cat=2}$ $CW^{Cat=3}$

Technological domain
(services/spare parts/ Human F)
[Medical Eng.]

Clinical domain
(effectiveness/utility)
[clinicians/cardiologists/ger.]

Economical domain
(costs)
[Hosp. Managers]

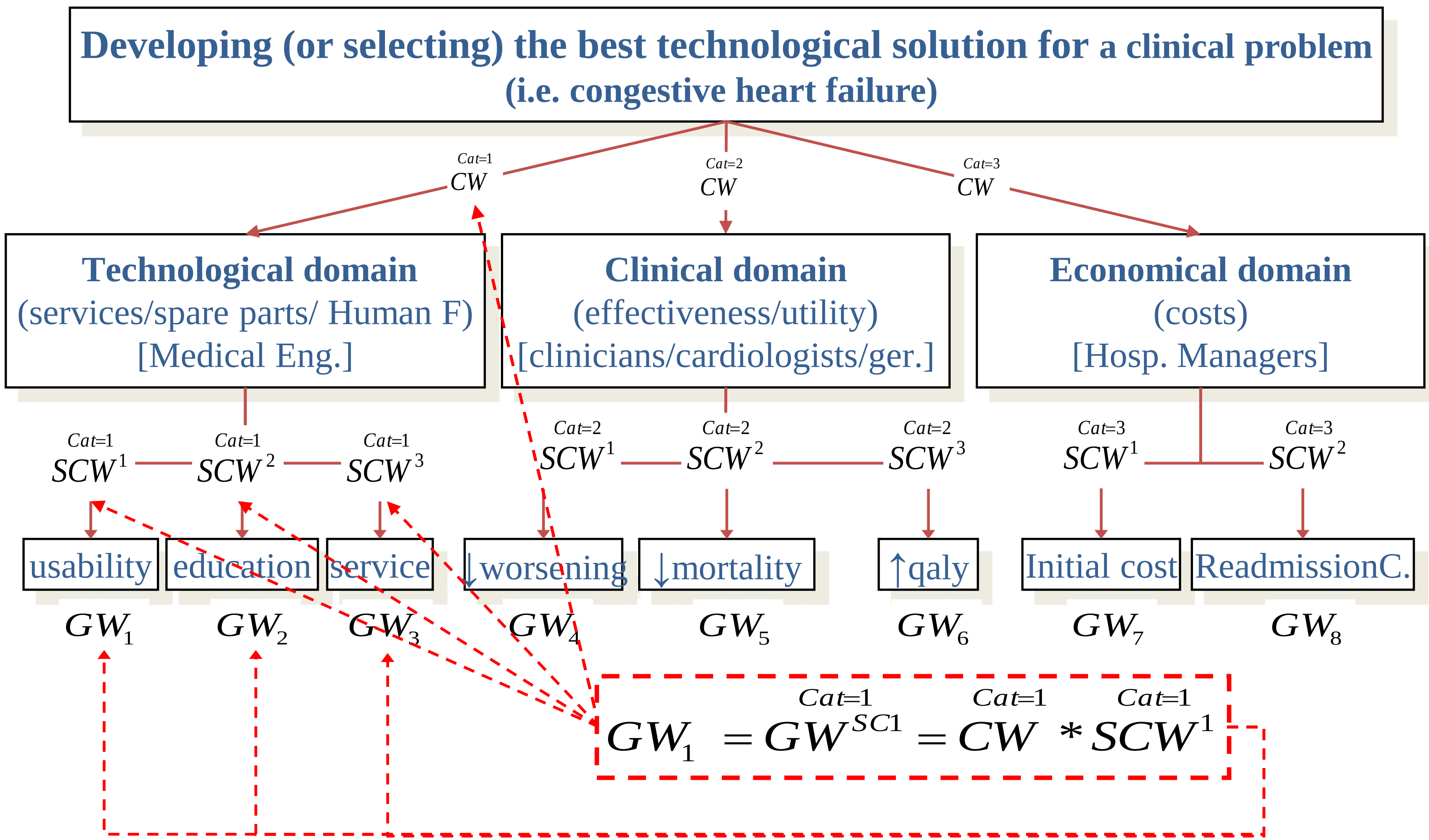
$SCW^{1}_{Cat=1}$ $SCW^{2}_{Cat=1}$ $SCW^{3}_{Cat=1}$ $SCW^{1}_{Cat=2}$ $SCW^{2}_{Cat=2}$ $SCW^{3}_{Cat=2}$ $SCW^{1}_{Cat=3}$ $SCW^{2}_{Cat=3}$

usability | education | service | ↓worsening | ↓mortality | ↑qaly | Initial cost | ReadmissionC.

According to your experience, how important is each need on the left compared with each one on the right?

Technological	Is:	*much more*	*more*	*equally*	~~*less*~~	*much less*	important hen	**Clinical**
Clinical	is:	~~*much more*~~	*more*	*equally*	*less*	*much less*	important hen	**Economical**
Economical	is :	*much more*	~~*more*~~	~~*equally*~~	*less*	*much less*	important hen	**Technological**

The Global Needs



The Global Needs

Developing (or selecting) the best technological solution for a clinical problem (i.e. congestive heart failure)

$\overset{Cat=1}{CW}$ $\overset{Cat=2}{CW}$ $\overset{Cat=3}{CW}$

Technological domain
(services/spare parts/ Human F)
[Medical Eng.]

Clinical domain
(effectiveness/utility)
[clinicians/cardiologists/ger.]

Economical domain
(costs)
[Hosp. Managers]

$\overset{Cat=1}{SCW^1}$ $\overset{Cat=1}{SCW^2}$ $\overset{Cat=1}{SCW^3}$ $\overset{Cat=2}{SCW^1}$ $\overset{Cat=2}{SCW^2}$ $\overset{Cat=2}{SCW^3}$ $\overset{Cat=3}{SCW^1}$ $\overset{Cat=3}{SCW^2}$

usability	education	service	↓worsening	↓mortality	↑qaly	Initial cost	ReadmissionC.
GW_1	GW_2	GW_3	GW_4	GW_5	GW_6	GW_7	GW_8

$$\overset{Cat=1}{GW_3} = GW^{SC3} = \overset{Cat=1}{CW} * \overset{Cat=1}{SCW^3}$$

$$\overset{Cat=1}{GW_2} = GW^{SC2} = \overset{Cat=1}{CW} * \overset{Cat=1}{SCW^2}$$

$$\overset{Cat=1}{GW_1} = GW^{SC1} = \overset{Cat=1}{CW} * \overset{Cat=1}{SCW^1}$$

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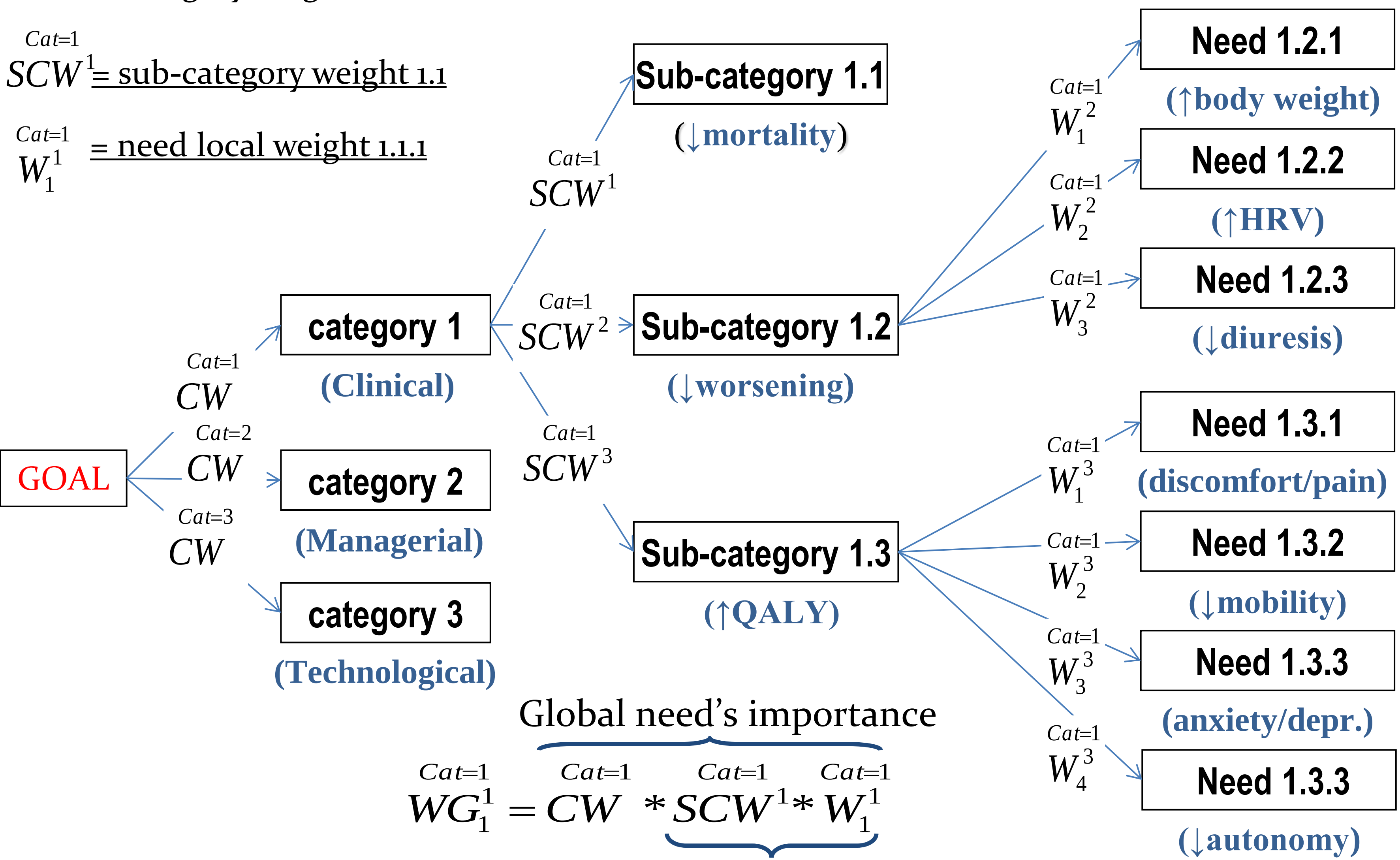
Need analysis: priority scaling (from local to global)

$\overset{Cat=1}{CW}$ = category weight 1

$\overset{Cat=1}{SCW^{1}}$ = sub-category weight 1.1

$\overset{Cat=1}{W_1^1}$ = need local weight 1.1.1



$$\overset{Cat=1}{WG_1^1} = \overbrace{\overset{Cat=1}{CW} * \underbrace{\overset{Cat=1}{SCW^1} * \overset{Cat=1}{W_1^1}}_{\text{Need's importance into its Category}}}^{\text{Global need's importance}}$$

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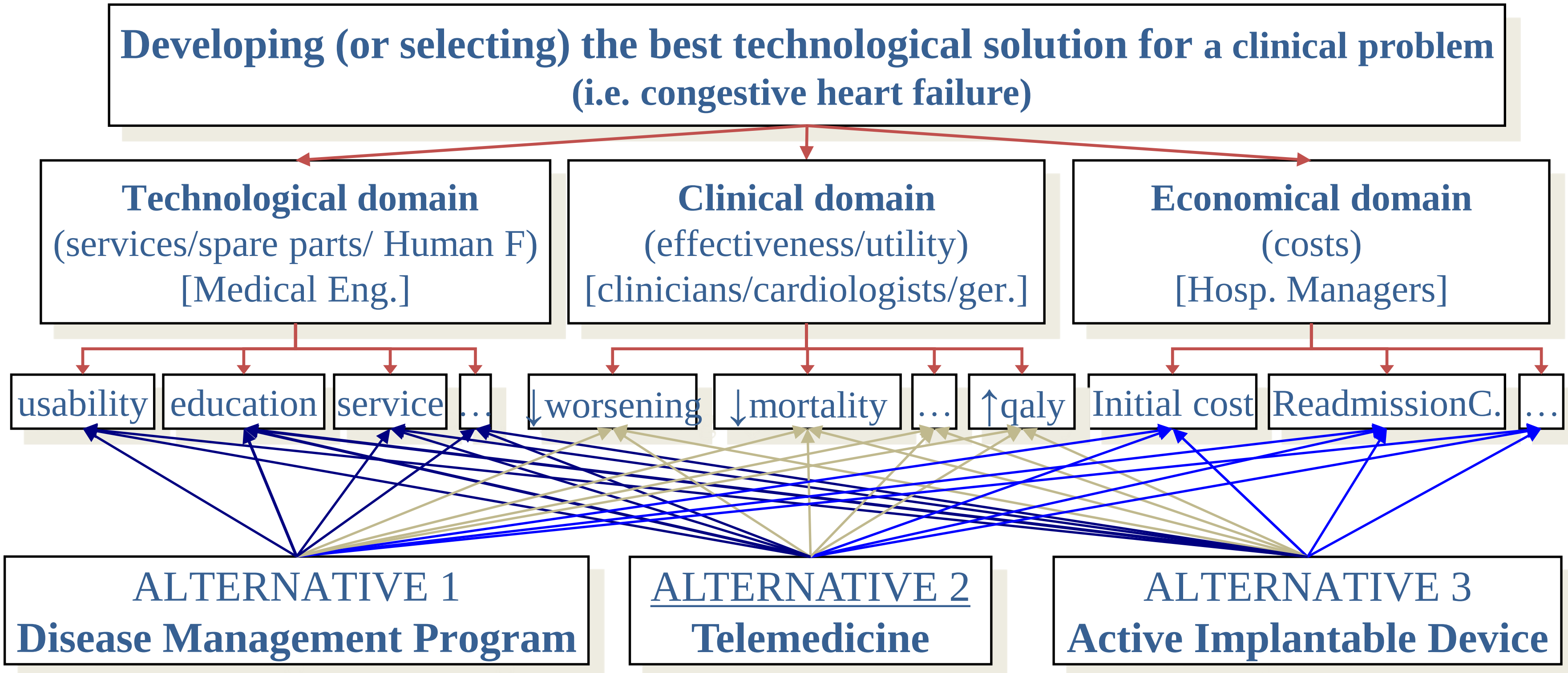
The alternatives



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The alternatives

ALTERNATIVE 1 Disease Management Program	ALTERNATIVE 2 Telemedicine	ALTERNATIVE 3 Active Implantable Device

- Now we have to compare each alternatives with all the other, investigating how effective are

*How effective is the alternative on right, compared with the left one, in reducing **worsening**?*

ALTERNATIVE 1 **Disease Management Program**	Is	*much more*	*more*	*equally*	*less*	*much less*	Important than	ALTERNATIVE 2 **Telemedicine**
ALTERNATIVE 2 **Telemedicine**	is	*much more*	*more*	*equally*	*less*	*much less*	Important than	ALTERNATIVE 3 **Active Implantable Device**
ALTERNATIVE 3 **Active Implantable Device**	is	*much more*	*more*	*equally*	*less*	*much less*	Important than	ALTERNATIVE 1 **Disease Management Program**

usability | education | service | ↓worsening | ↓mortality | ↑qaly | Initial cost | ReadmissionC.

Global Performance

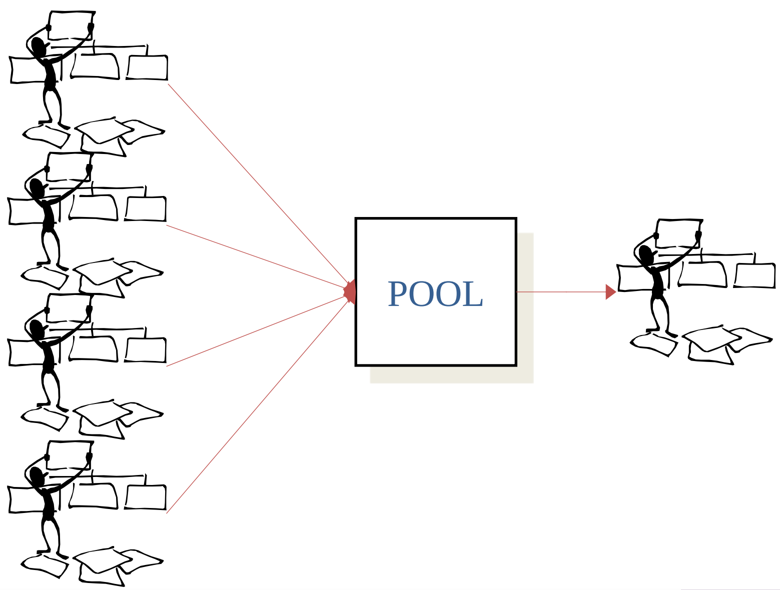
	Global importance	ALTERNATIVE 1 **DMP**	ALTERNATIVE 2 **Telemedicine**	ALTERNATIVE 3 **Active Implantable D.**
usability	GW_1	P_1^{A1}	P_1^{A2}	P_1^{A3}
education	GW_2	P_2^{A1}	P_2^{A2}	P_2^{A3}
service	GW_3	P_3^{A1}	P_3^{A2}	P_3^{A3}
↓worsening	GW_4	P_4^{A1}	P_4^{A2}	P_4^{A3}
↓mortality	GW_5	P_5^{A1}	P_5^{A2}	P_5^{A3}
↑qaly	GW_6	P_6^{A1}	P_6^{A2}	P_6^{A3}
Initial cost	GW_7	P_7^{A1}	P_7^{A2}	P_7^{A3}
ReadmissionC.	GW_8	P_8^{A1}	P_8^{A2}	P_8^{A3}

$$Global\ Perfomance\ Alternative_j = \sum_{i=1}^{8} GW_i * P_i^{Aj}$$

Group Decision Making

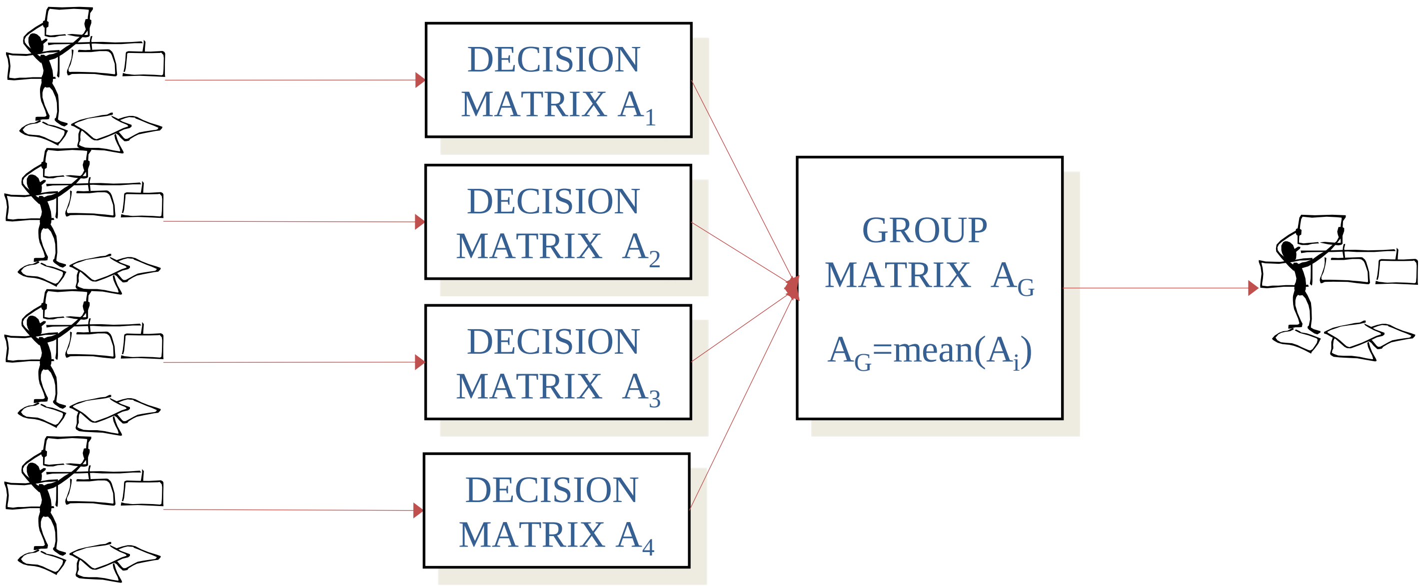
- What can I do if there are several decision-makers?

- There are two main approaches:
  - Find consensus:
    - Several decision-makers discuss and give one answers for the whole group
    - Each decision-makers gives his/her answers and then the group discuss individual differences arriving to a group decision
  - Pool their priorities:



Group Decision Making

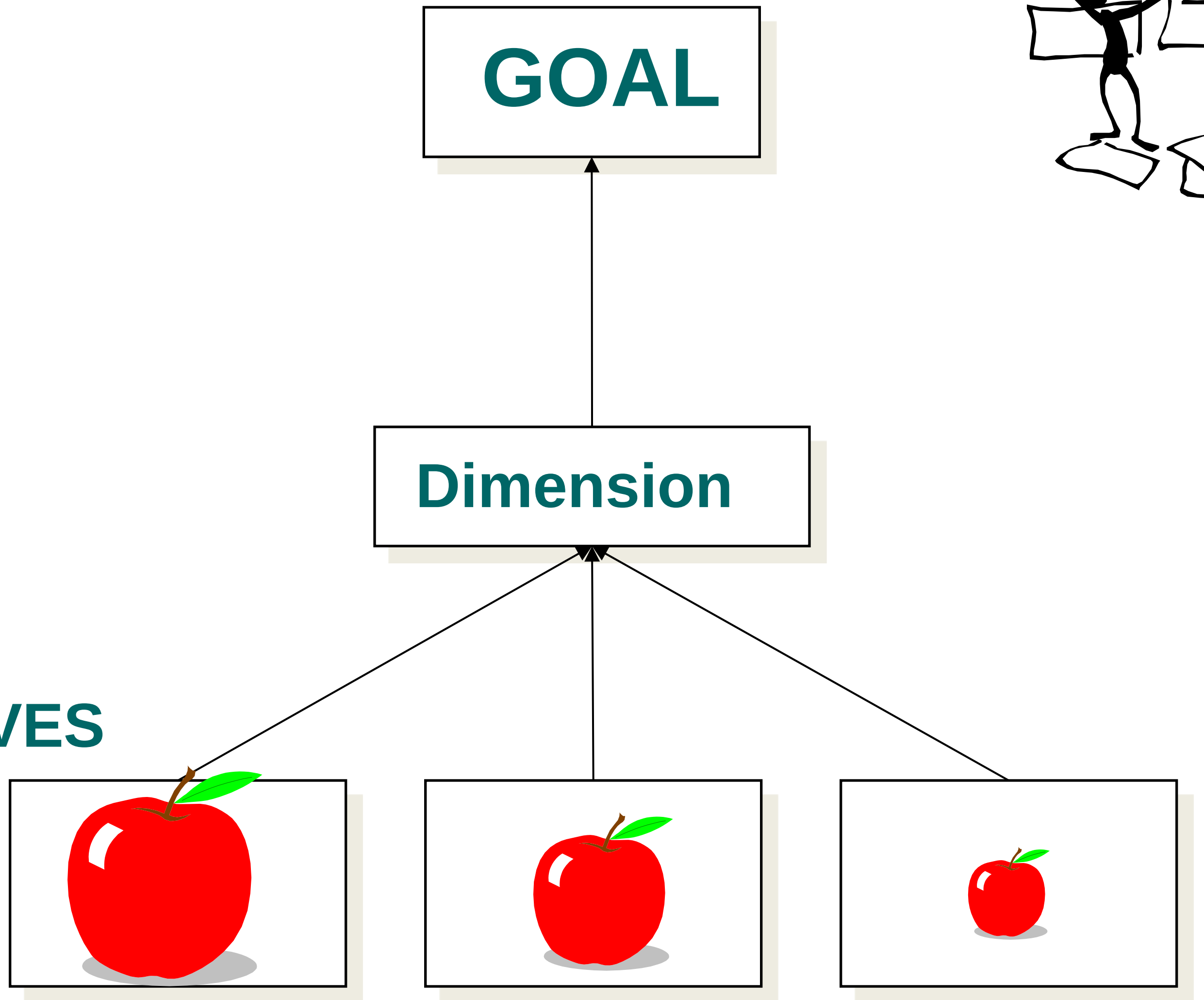
- How can I aggregate individual preferences?



- Which average?
  - Algebraic mean

Applications

• The study on Home Monitoring for Hearth Failure	ISAHP2009, Pittsburgh, USA
• An application on Elderly Well being	ISAHP2007, Naples, Italy
• The selection of a Contract of Maintenance	WC2009, Munch, Germany
• A study on a Device for Epinefrine autoinjection	HIS2013, London, UK
• A user need elicitation for the use of a CT Scanner	ISAHP2007, Naples, Italy
• AHP and early stage HTA	WC2012, Beijing, China

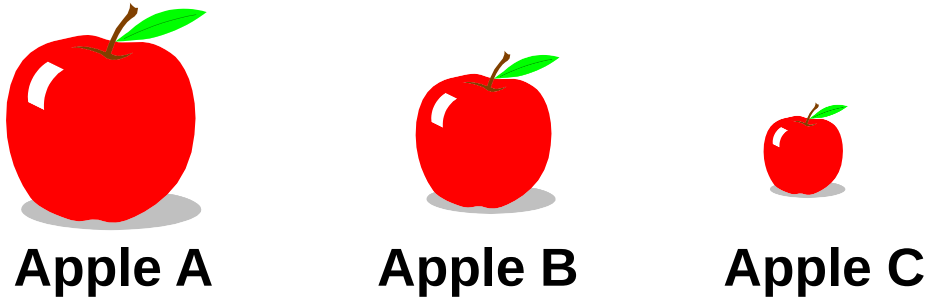


CRITERIA

ALTERNATIVES

Comparison Matrix

Given: Three apples of different sizes.



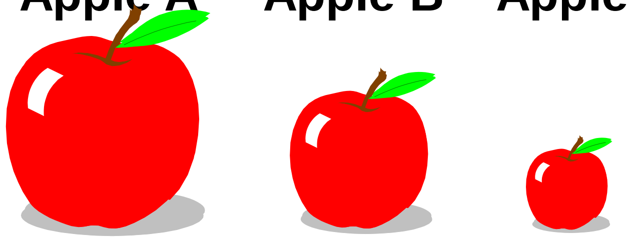
We assess their Relative sizes by forming ratios

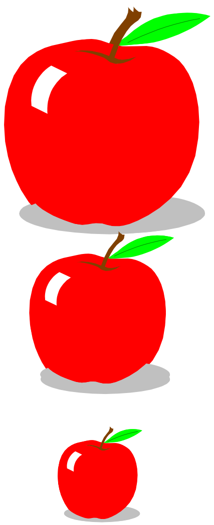
Size Comparison	Apple A	Apple B	Apple C
Apple A	S_1/S_1	S_1/S_2	S_1/S_3
Apple B	S_2 / S_1	S_2 / S_2	S_2 / S_3
Apple C	S_3 / S_1	S_3 / S_2	S_3 / S_3

Pairwise Comparisons

GOAL

Apple A | Apple B | Apple C

Size Comparison	Apple A	Apple B	Apple C	Resulting Priority Eigenvector	Relative Size of Apple
					
Apple A					A
Apple B					B
Apple C					C



When the judgments are consistent, as they are here, any normalized column gives the priorities.

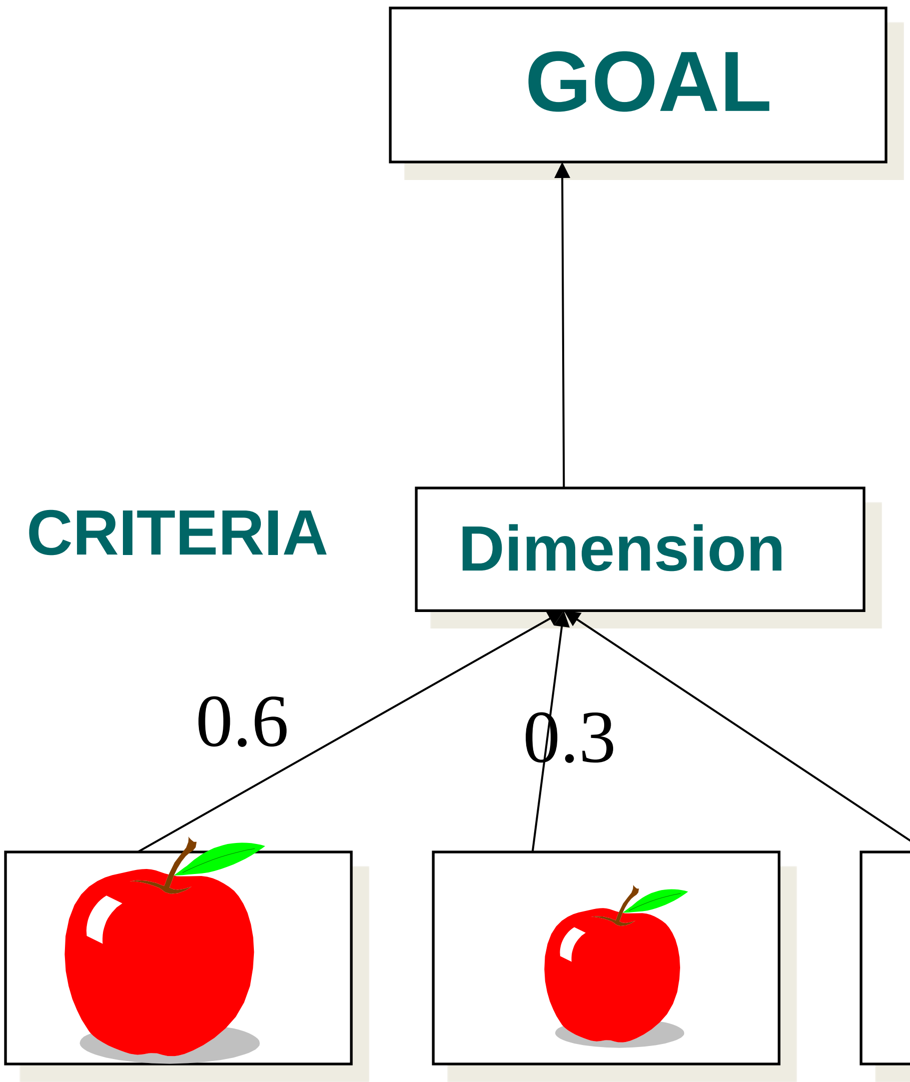
$$\begin{cases} A = 2B \\ A = 6C \\ B = 3C \end{cases} \Leftrightarrow \begin{cases} A = 6C \\ B = 3C \end{cases} \Leftrightarrow \begin{cases} A = 6C \\ B = 3C \\ C = 1 \end{cases}$$

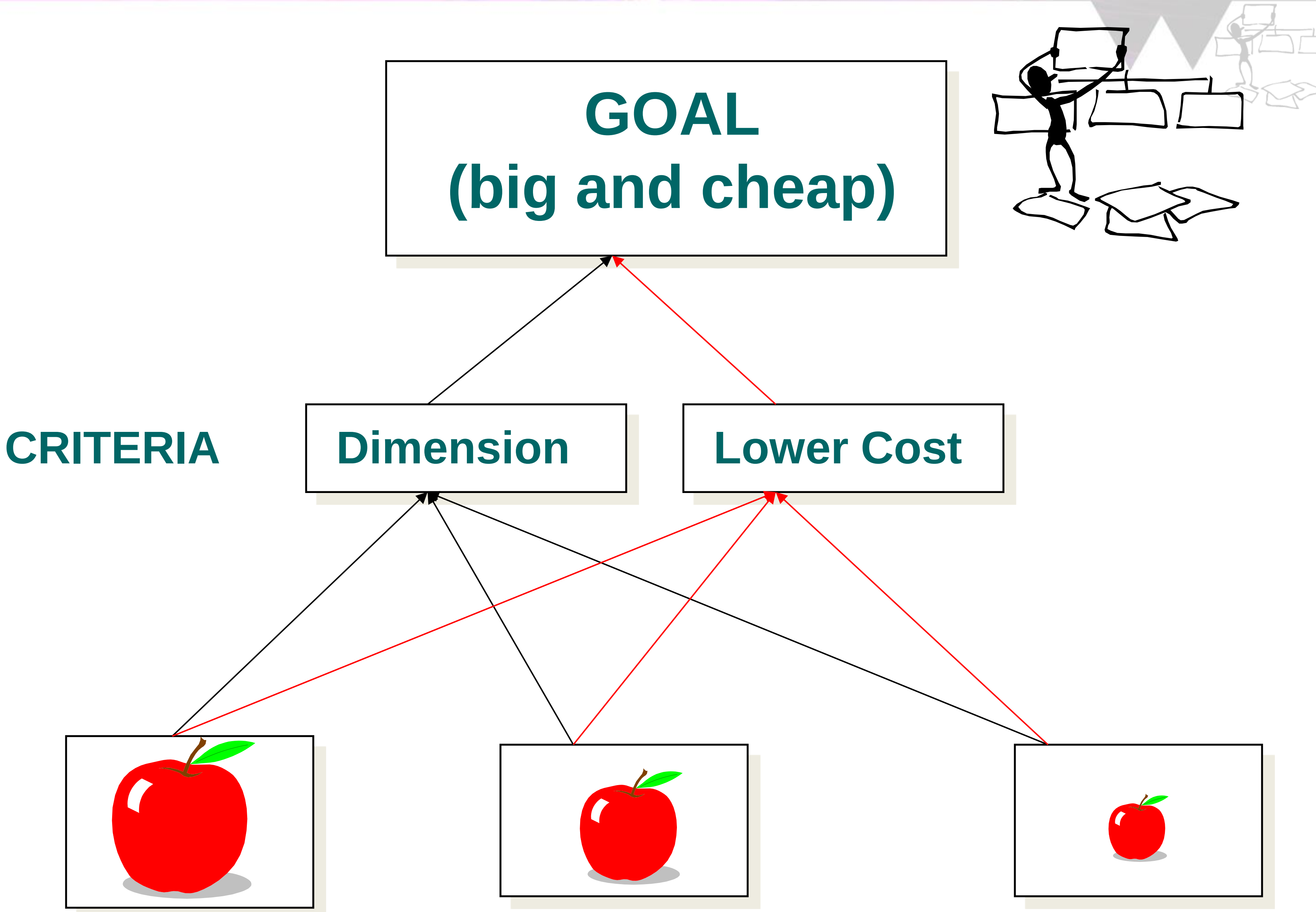
Normalizing to the max (6):

$$\begin{cases} A = 1 \\ B = 0.5 \\ C = 1.67 \end{cases}$$

Normalizing to the tot (6+3+1=10):

$$\begin{cases} A = 0.6 \\ B = 0.3 \\ C = 0.1 \end{cases}$$

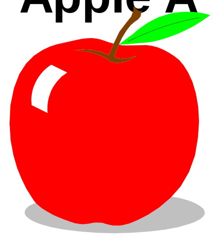
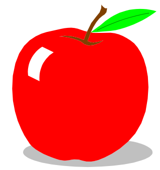
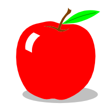
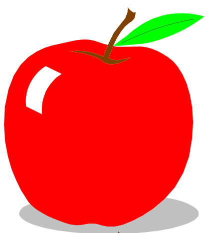
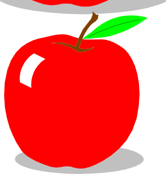
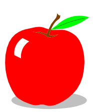

GOAL
CRITERIA
Dimension
0.6
0.3
0.1


GOAL
(big and cheap)
CRITERIA
Dimension
Lower Cost

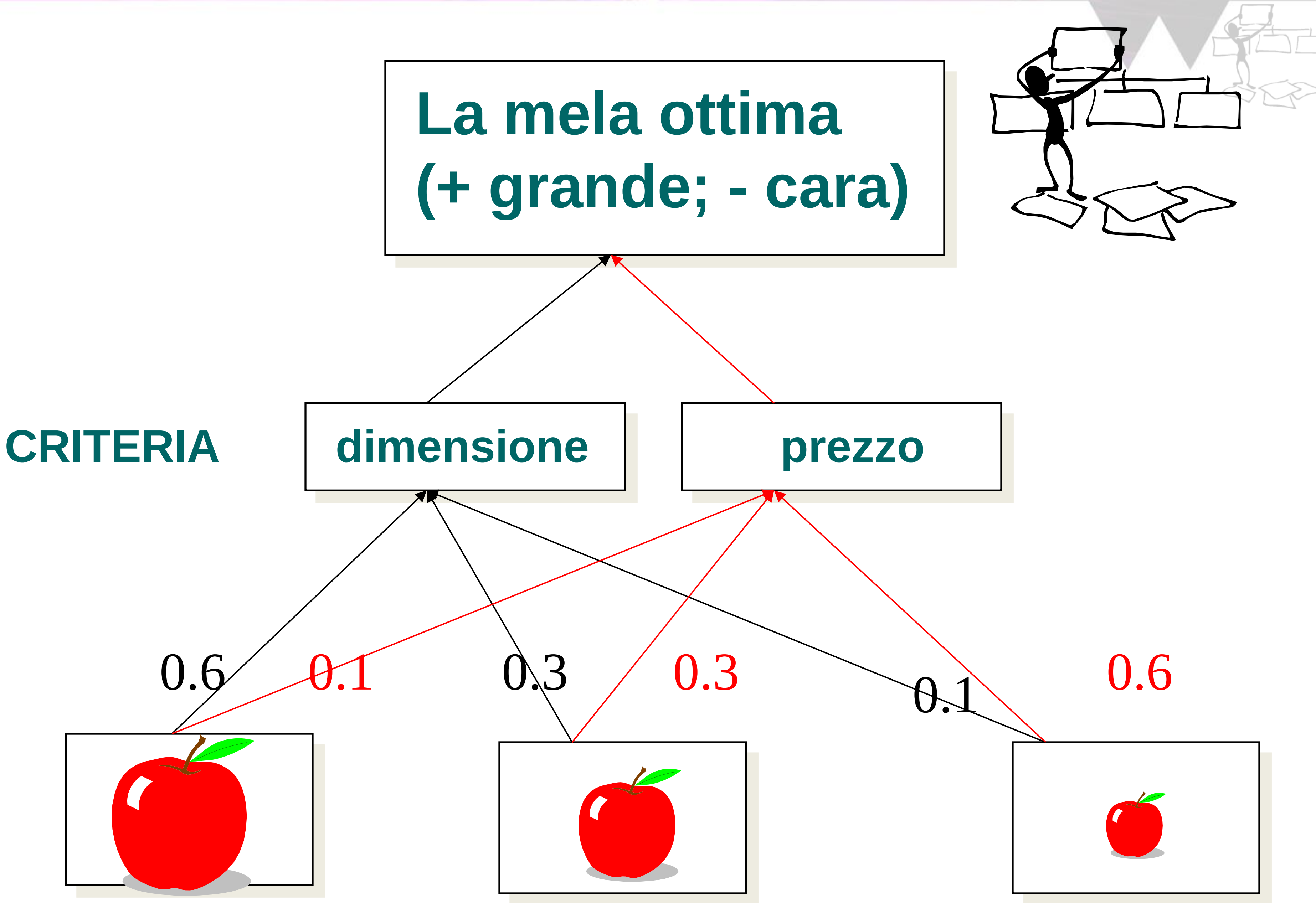
Pairwise Comparisons

Prezzo

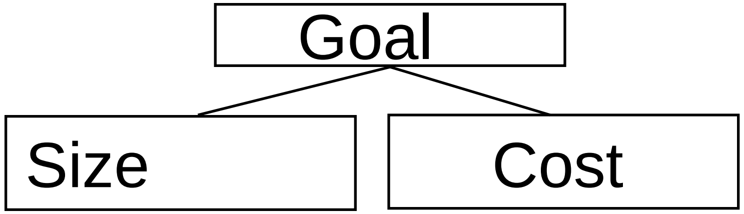
Apple A | Apple B | Apple C

Size Comparison	Apple A 	Apple B 	Apple C 	Resulting Priority Eigenvector	Relative Size of Apple
 Apple A	1	1/3	1/6	1/10	A
 Apple B	3	1	1/2	3/10	B
 Apple C	6	2	1	6/10	C

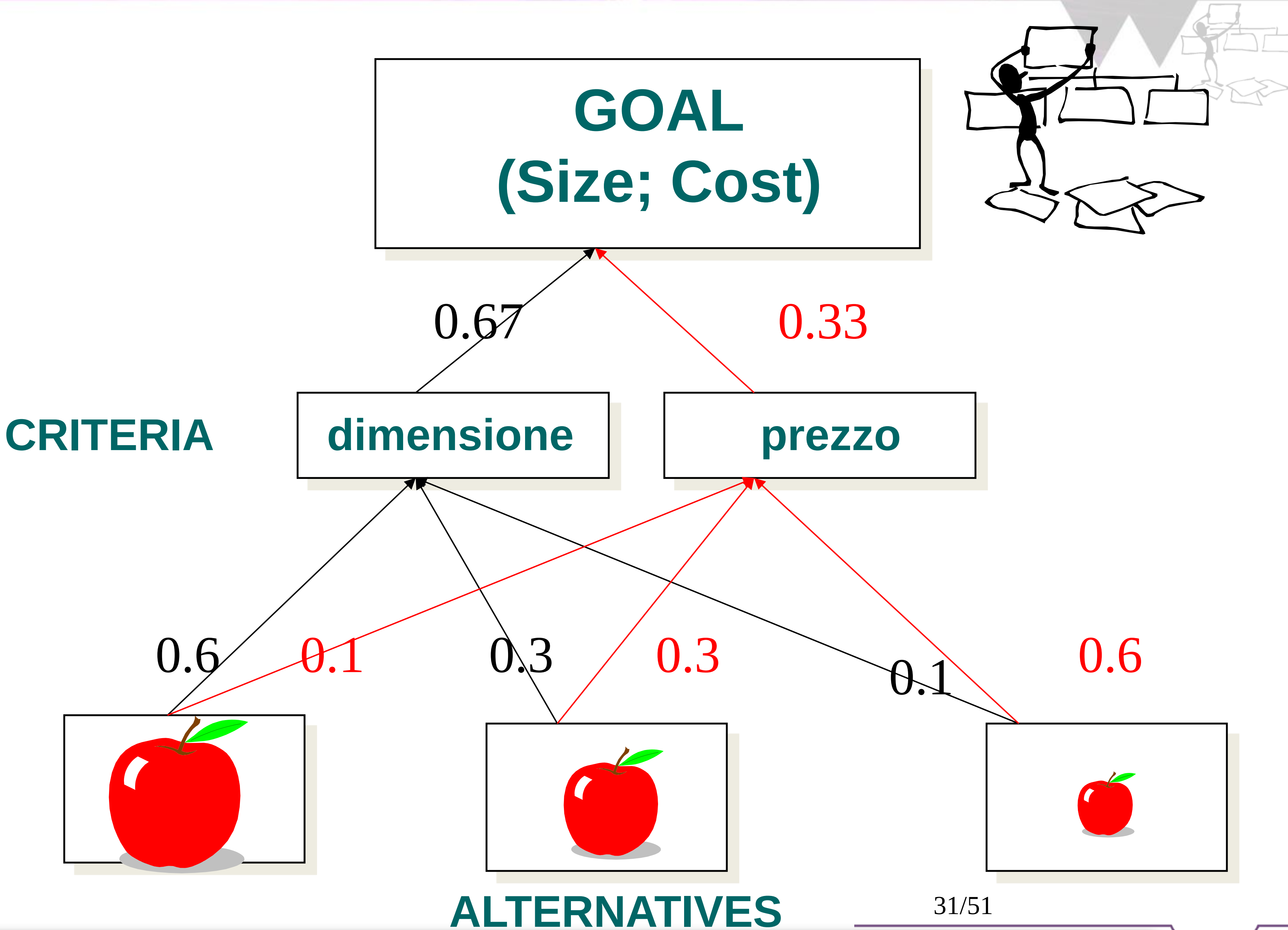
When the judgments are consistent, as they are here, any normalized column gives the priorities.

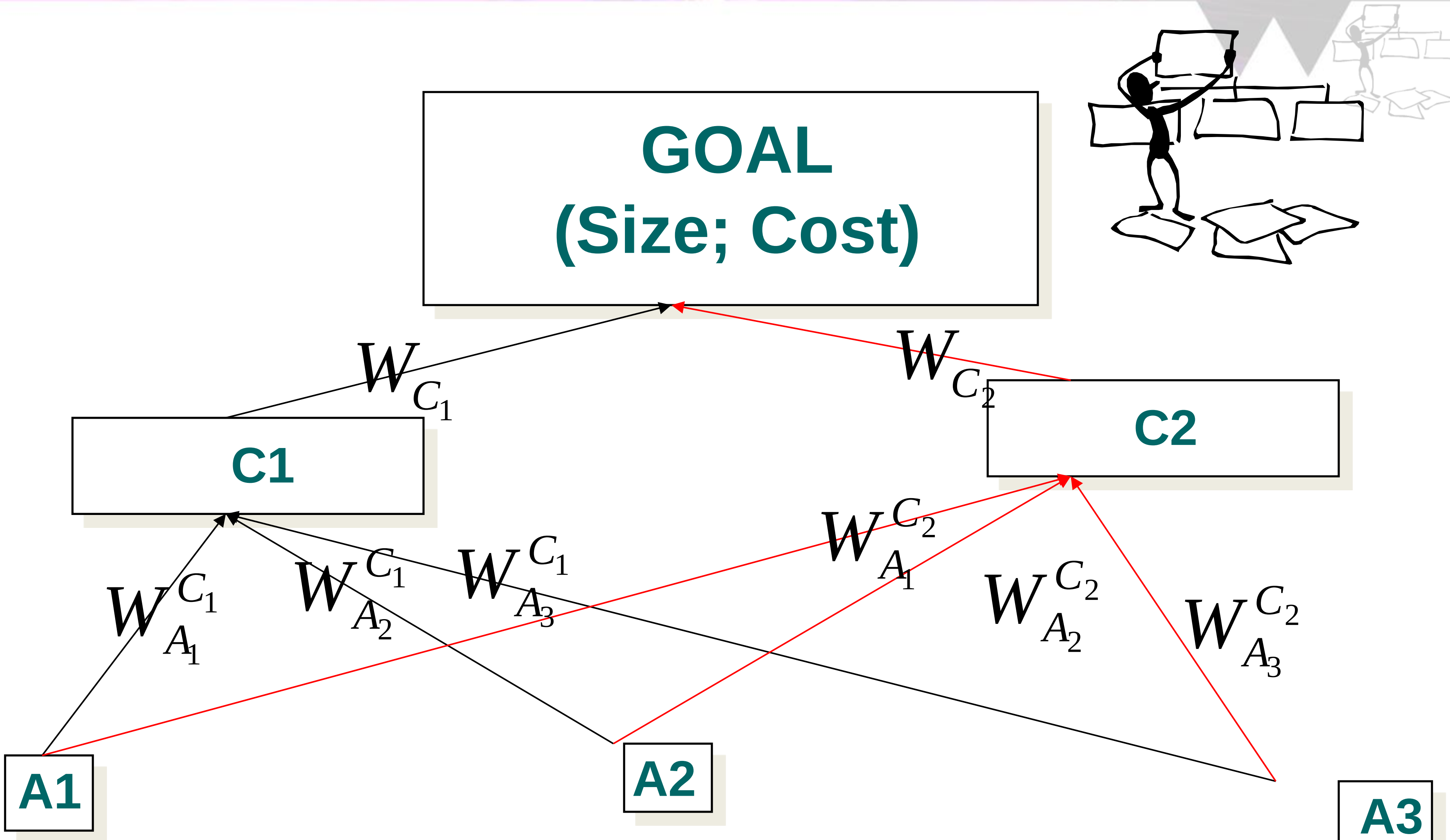

La mela ottima
(+ grande; - cara)
CRITERIA
dimensione
prezzo
0.6
0.1
0.3
0.3
0.1
0.6
ALTERNATIVES

Pairwise Comparisons

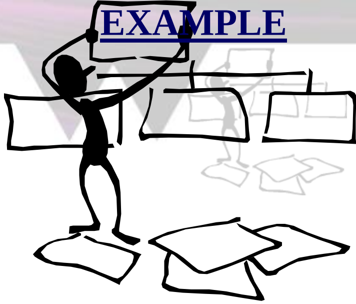


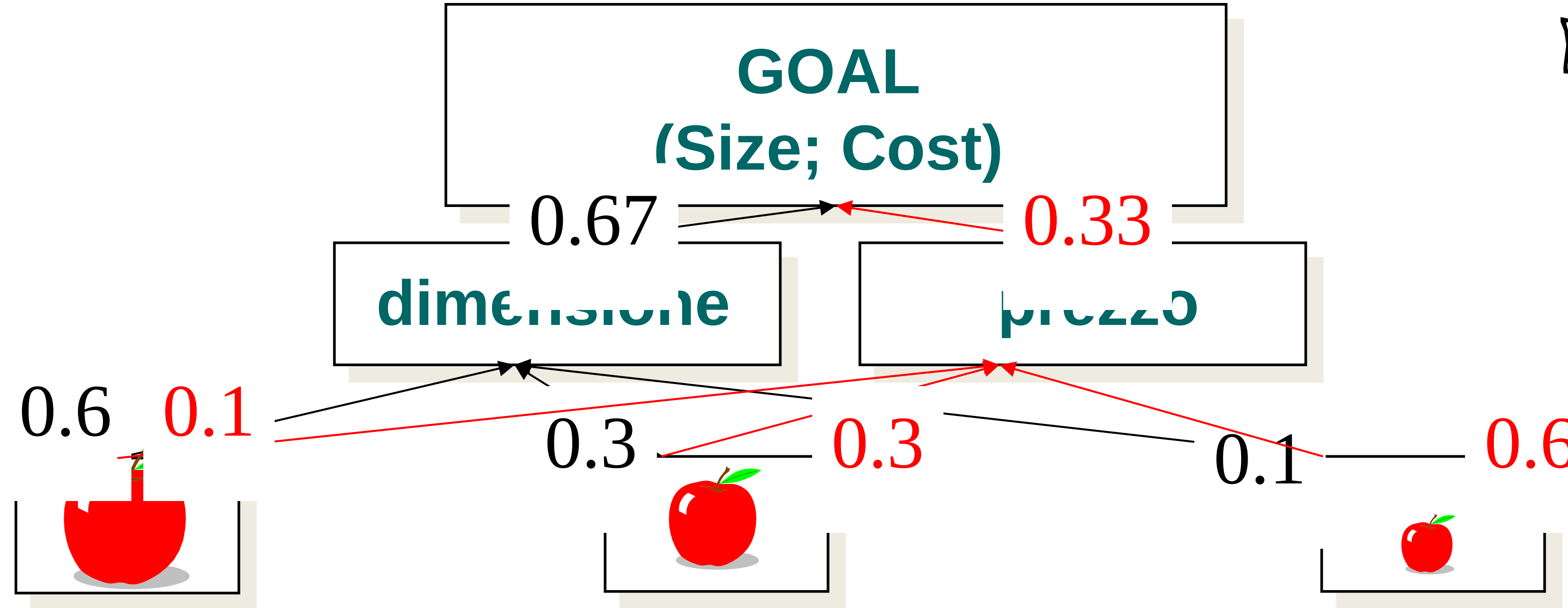
	Size	Cost	Priority Eigenvector	Normalized (al tot)
Size	1	2	0.89	0,67
Cost	0.5	1	0.45	0.33


GOAL
(Size; Cost)
0.67
0.33
CRITERIA
dimensione
prezzo
0.6
0.1
0.3
0.3
0.1
0.6
ALTERNATIVES



$$P_{A_1} = \sum_{i=1}^{n_{c_j}=2} W_{C_j} * W_{A_1}^{C_i} = \left(W_{C_1} ; W_{C_2}\right) * \begin{pmatrix} W_{A_1}^{C_1} \\ W_{A_1}^{C_2} \end{pmatrix} = \vec{W}_c * \vec{W}_{A_1}^{C}$$





$$P_{A1} = (0{,}67;0{,}33) * \begin{pmatrix} 0{,}6 \\ 0{,}1 \end{pmatrix} = 0{,}435$$

$$P_{A2} = (0{,}67;0{,}33) * \begin{pmatrix} 0{,}3 \\ 0{,}3 \end{pmatrix} = 0{,}3$$

$$P_{A3} = (0{,}67;0{,}33) * \begin{pmatrix} 0{,}1 \\ 0{,}6 \end{pmatrix} = 0{,}265$$

GOAL
(Size; Cost)

$$W_{C_1} * W_{A_1}^{C_1} + W_{C_2} * W_{A_1}^{C_2}$$

A1

$$W_{C_1} * W_{A_3}^{C_1} + W_{C_2} * W_{A_3}^{C_2}$$

A3

$$W_{C_1} * W_{A_2}^{C_1} + W_{C_2} * W_{A_2}^{C_2}$$

A2