http://www.rss.org.uk/site/cms/contentEventViewEvent.asp?chapter=9&e=1543

ROYAL STATISTICAL SOCIETY

STATISTICS VIEWS

On Generating High InfoQ with Bayesian Networks

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$$InfoQ(f, X, g) = U(f(X|g))$$

Examples from:

- Customer surveys
- Risk management of telecom systems
- Monitoring of bioreactors
- Managing healthcare of diabetic patients

Primary Data

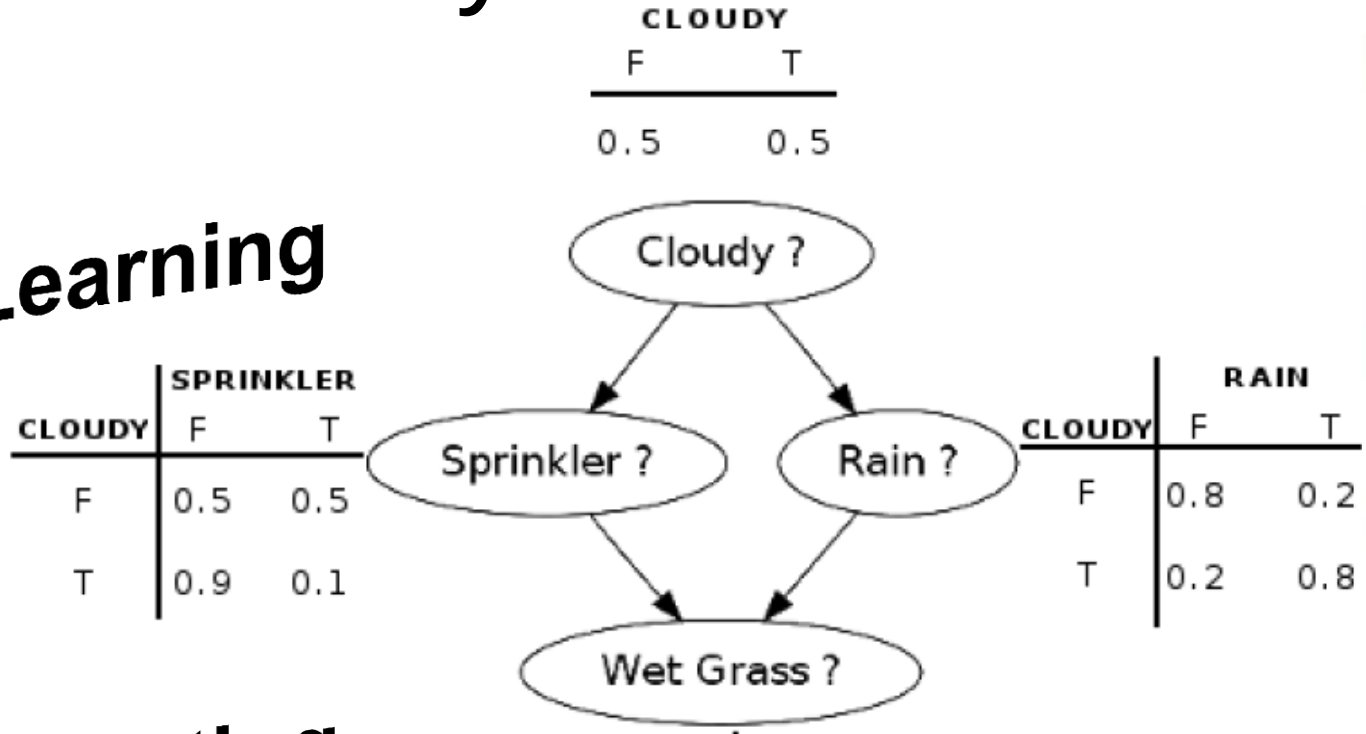
- Experimental
- Observational

Secondary Data

- Experimental
- Observational

Bayesian Networks

Learning



Estimating

RAIN	SPRINKLER	WET GRASS F	WET GRASS T
F	F	1	0
F	T	0.1	0.9
T	F	0.1	0.9
T	T	0.01	0.99

Programmer's nightmare:

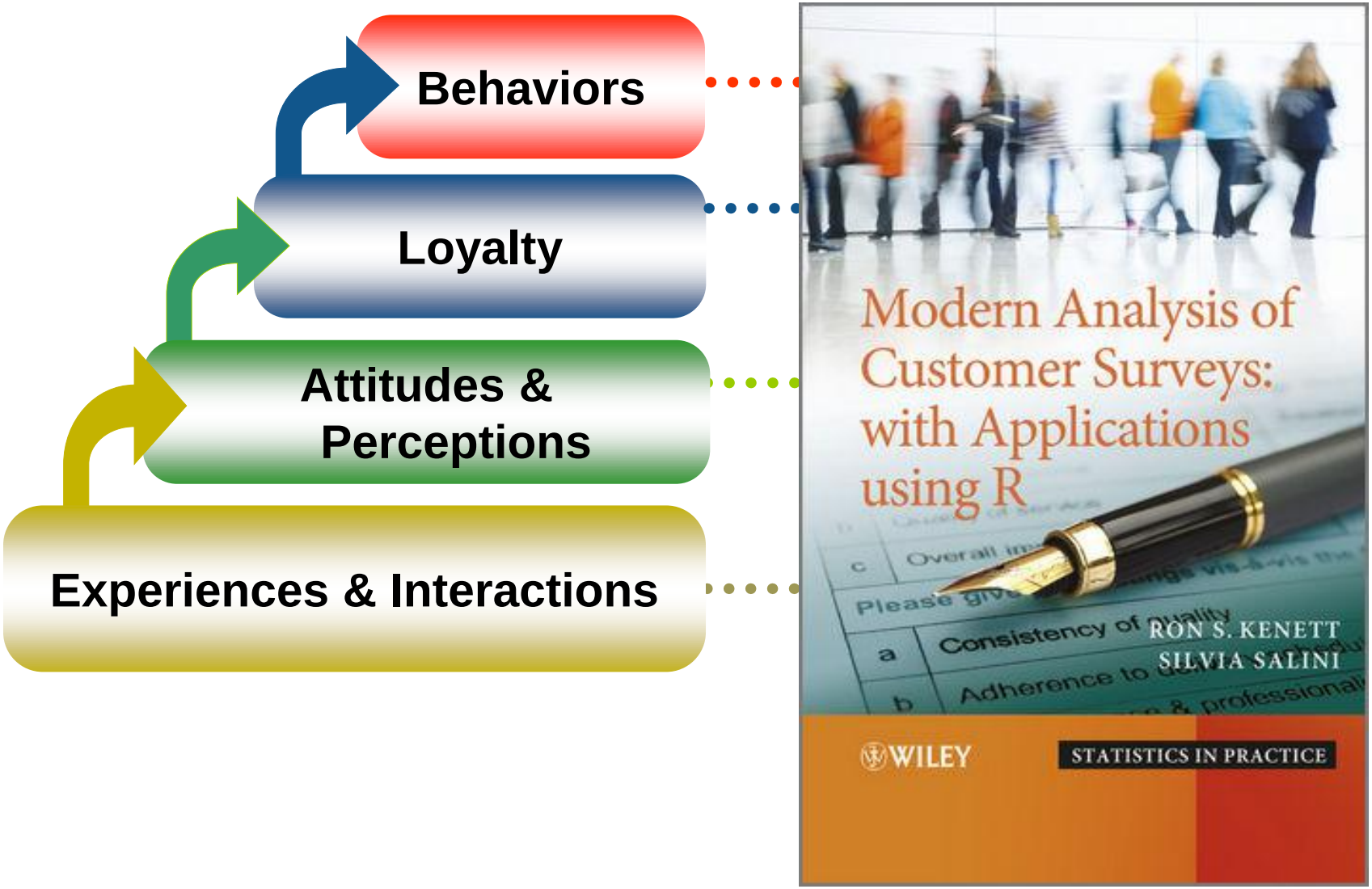
1. "If the grass is wet, then it rained"
2. "if the sprinkler is on, the grass will get wet"

Output: "If the sprinkler is on, then it rained"

Judea Pearl
2011 Turing Medalist

- Causal calculus
- Counterfactuals
- Do calculus
- Transportability
- Missing data
- Causal mediation
- Graph mutilation
- External validity

Customer Surveys



Customer Surveys Goals

Goal 1.	**Decide** where to launch improvement initiatives
Goal 2.	**Highlight** drivers of overall satisfaction
Goal 3.	**Detect** positive or negative trends in customer satisfaction
Goal 4.	**Identify** best practices by comparing products or marketing channels
Goal 5.	**Determine** strengths and weaknesses
Goal 6.	**Set up** improvement goals
Goal 7.	**Design** a balanced scorecard with customer inputs
Goal 8.	**Communicate** the results using graphics
Goal 9.	**Assess** the reliability of the questionnaire
Goal 10.	**Improve** the questionnaire for future use

$$InfoQ(f,X,g) = U(f(X|g))$$

The ABC 2010 Annual Customer Satisfaction Survey

Company: _____

Completed by: _____

Title/Position: 1. Owner 2. Management 3. Technical Management 4. Technical Sta
5. Operator 6. Administrator 7. Other, please specify: _____

Dear Customer,

For each of the following statements, please select a number indicating the extent of your agreement with the statement concerning your experience with ABC during 2010. Then, under "Importance Level", select another number indicating the importance of the statement to you. If a certain statement is not relevant or not applicable, please select N/A.

Overall Satisfaction from ABC

		Evaluation				
		Very low				Very high
1.	Overall satisfaction level from ABC:	1	2	3	4	5
2.	Overall satisfaction level from ABC's improvements during 2010:	1	2	3	4	5
3.	Is ABC your best supplier?	a. Yes b. No				
		Very unlikely				Very likely
4.	Would you recommend ABC to other companies?	1	2	3	4	5
5.	If you were in the market to buy a PRODUCT, how likely would it be for you to purchase an ABC product again?	1	2	3	4	5

Equipment and System

		Evaluation					Importance Level			
		Strongly disagree				Strongly agree	Low		High	
6.	The equipment's features and capabilities meet your needs.	1	2	3	4	5	1	2	3	N/A
7.	Improvements and upgrades provide value.	1	2	3	4	5	1	2	3	N/A
8.	Output quality meets or exceeds expectations.	1	2	3	4	5	1	2	3	N/A
9.	Uptime is acceptable.	1	2	3	4	5	1	2	3	N/A
10.	For customers who purchased a system during 2010: ABC's equipment proposal met your requirements.	1	2	3	4	5	1	2	3	N/A
		Very low				Very high				
11.	Overall satisfaction level from the **equipment**:	1	2	3	4	5				

Sales Support

		Evaluation					Importance Level			
		Strongly disagree				Strongly agree	Low		High	
12.	Verbal promises have been honored.	1	2	3	4	5	1	2	3	N/A
13.	Sales personnel communicate frequently enough with you.	1	2	3	4	5	1	2	3	N/A
14.	Sales personnel respond promptly to requests.	1	2	3	4	5	1	2	3	N/A
15.	Sales personnel are knowledgeable about equipment.	1	2	3	4	5	1	2	3	N/A
16.	Sales personnel are knowledgeable about market opportunities.	1	2	3	4	5	1	2	3	N/A
		Very low				Very high				
17.	Overall satisfaction level from **sales support**:	1	2	3	4	5				

Technical Support

		Evaluation					Importance Level			
		Strongly disagree				Strongly agree	Low		High	
18.	Technical support is available when needed.	1	2	3	4	5	1	2	3	N/A
19.	The technical staff is knowledgeable.	1	2	3	4	5	1	2	3	N/A
20.	The technical staff is well informed about the latest equipment updates/enhancements.	1	2	3	4	5	1	2	3	N/A
21.	Parts are available when needed.	1	2	3	4	5	1	2	3	N/A
22.	The remote support care center is valuable and meets your expectations.	1	2	3	4	5	1	2	3	N/A
23.	Problems are resolved within the required time frame.	1	2	3	4	5	1	2	3	N/A
24.	The technical staff is courteous and helpful.	1	2	3	4	5	1	2	3	N/A
		Very low				Very high				
25.	Overall satisfaction level from **technical support**:	1	2	3	4	5				

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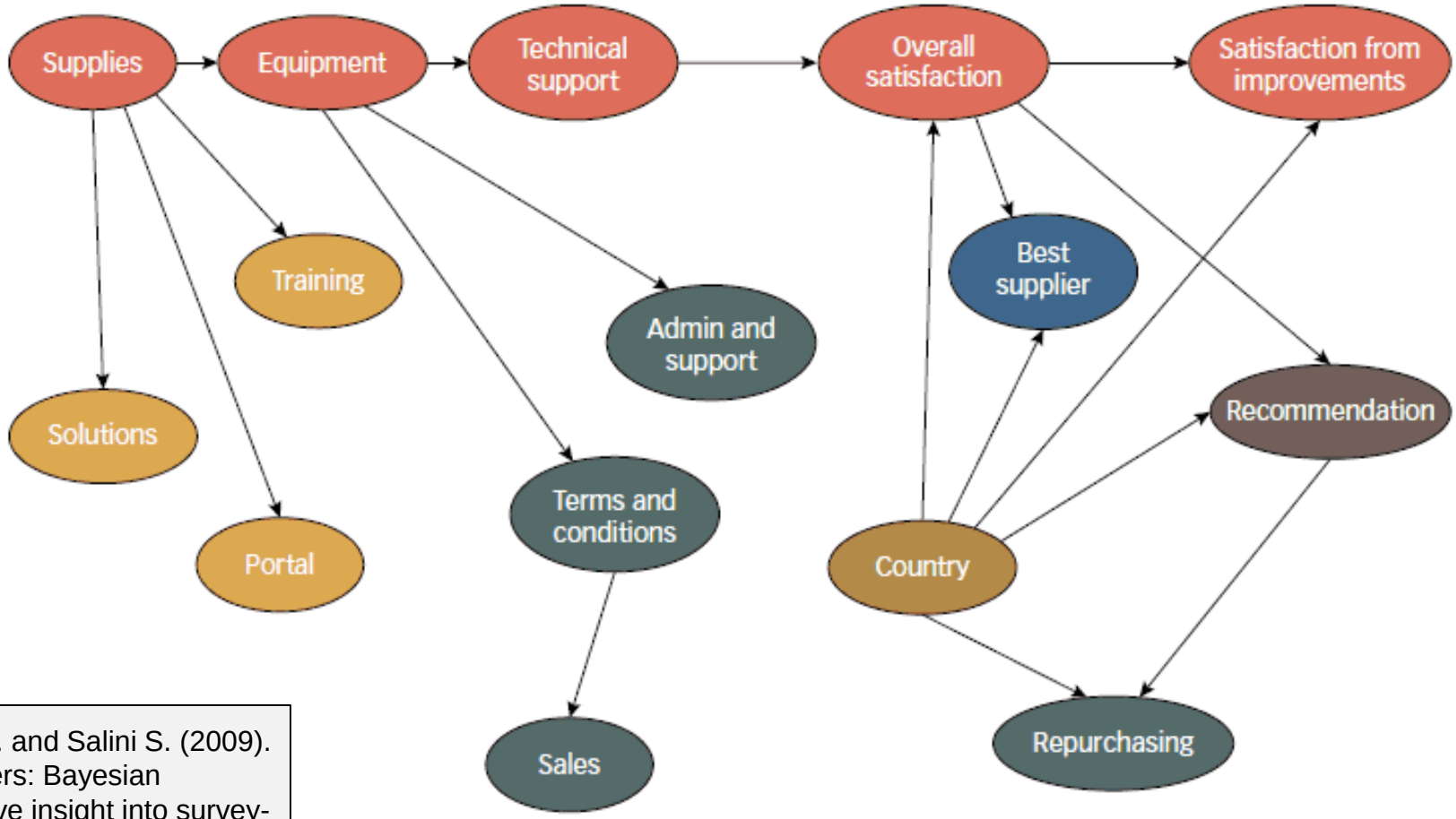
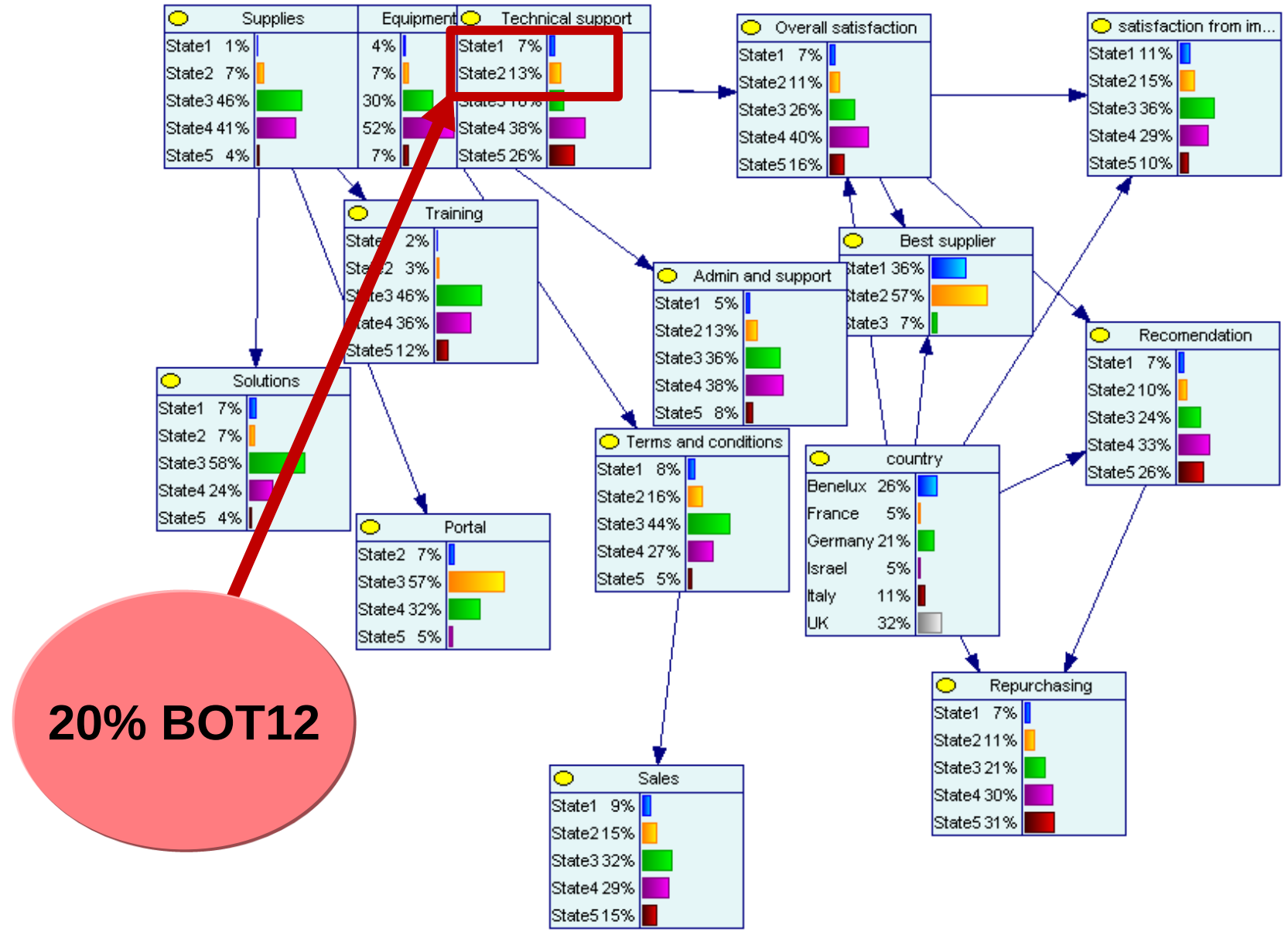
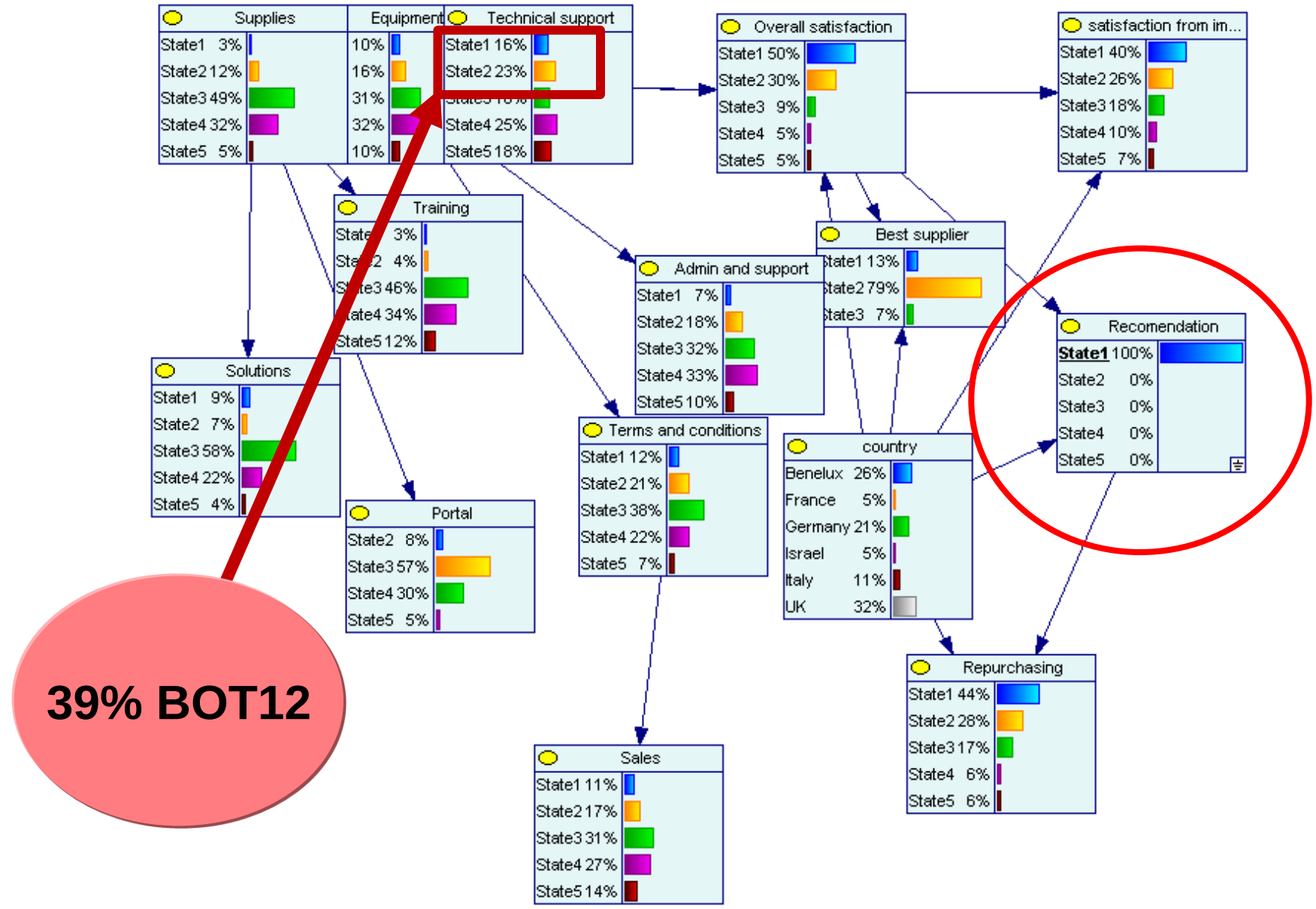
Bayesian Network Analysis of Customer Surveys



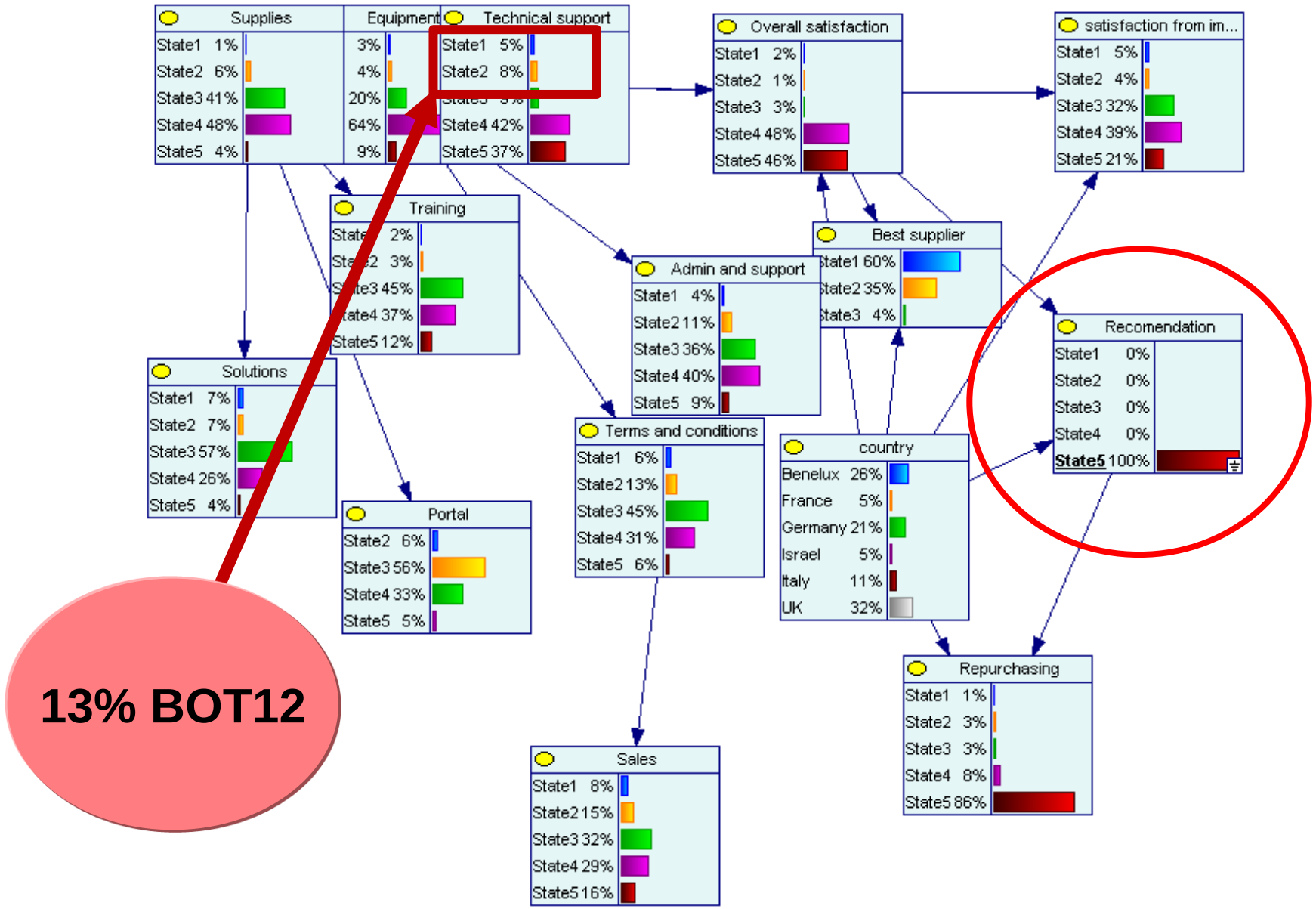
Kenett, R.S. and Salini S. (2009). New Frontiers: Bayesian networks give insight into survey-data analysis, *Quality Progress*, pp. 31-36, August.


Supplies
State1 1%
State2 7%
State3 46%
State4 41%
State5 4%
Equipment
4%
7%
30%
52%
7%
Technical support
State1 7%
State2 13%
State4 38%
State5 26%
Overall satisfaction
State1 7%
State2 11%
State3 26%
State4 40%
State5 16%
satisfaction from im...
State1 11%
State2 15%
State3 36%
State4 29%
State5 10%
Training
2%
3%
State3 46%
State4 36%
State5 12%
Best supplier
State1 36%
State2 57%
State3 7%
Admin and support
State1 5%
State2 13%
State3 36%
State4 38%
State5 8%
Recomendation
State1 7%
State2 10%
State3 24%
State4 33%
State5 26%
Solutions
State1 7%
State2 7%
State3 58%
State4 24%
State5 4%
Terms and conditions
State1 8%
State2 16%
State3 44%
State4 27%
State5 5%
country
Benelux 26%
France 5%
Germany 21%
Israel 5%
Italy 11%
UK 32%
Portal
State2 7%
State3 57%
State4 32%
State5 5%
Repurchasing
State1 7%
State2 11%
State3 21%
State4 30%
State5 31%
Sales
State1 9%
State2 15%
State3 32%
State4 29%
State5 15%
20% BOT12

8


Supplies
State1 3%
State2 12%
State3 49%
State4 32%
State5 5%
Equipment
10%
16%
31%
32%
10%
Technical support
State1 16%
State2 23%
State4 25%
State5 18%
Overall satisfaction
State1 50%
State2 30%
State3 9%
State4 5%
State5 5%
satisfaction from im...
State1 40%
State2 26%
State3 18%
State4 10%
State5 7%
Training
3%
4%
46%
34%
12%
Best supplier
13%
79%
7%
Admin and support
State1 7%
State2 18%
State3 32%
State4 33%
State5 10%
Recomendation
State1 100%
State2 0%
State3 0%
State4 0%
State5 0%
Solutions
State1 9%
State2 7%
State3 58%
State4 22%
State5 4%
Terms and conditions
State1 12%
State2 21%
State3 38%
State4 22%
State5 7%
country
Benelux 26%
France 5%
Germany 21%
Israel 5%
Italy 11%
UK 32%
Portal
State2 8%
State3 57%
State4 30%
State5 5%
39% BOT12
Repurchasing
State1 44%
State2 28%
State3 17%
State4 6%
State5 6%
Sales
State1 11%
State2 17%
State3 31%
State4 27%
State5 14%

9


Supplies
State1 1%
State2 6%
State3 41%
State4 48%
State5 4%
Equipment
3%
4%
20%
64%
9%
Technical support
State1 5%
State2 8%
State4 42%
State5 37%
Overall satisfaction
State1 2%
State2 1%
State3 3%
State4 48%
State5 46%
satisfaction from im...
State1 5%
State2 4%
State3 32%
State4 39%
State5 21%
Training
State 2%
State2 3%
State3 45%
State4 37%
State5 12%
Best supplier
State1 60%
State2 35%
State3 4%
Admin and support
State1 4%
State2 11%
State3 36%
State4 40%
State5 9%
Recomendation
State1 0%
State2 0%
State3 0%
State4 0%
State5 100%
Solutions
State1 7%
State2 7%
State3 57%
State4 26%
State5 4%
Terms and conditions
State1 6%
State2 13%
State3 45%
State4 31%
State5 6%
country
Benelux 26%
France 5%
Germany 21%
Israel 5%
Italy 11%
UK 32%
Portal
State2 6%
State3 56%
State4 33%
State5 5%
Repurchasing
State1 1%
State2 3%
State3 3%
State4 8%
State5 86%
Sales
State1 8%
State2 15%
State3 32%
State4 29%
State5 16%
13% BOT12

10

Information Quality (InfoQ) of Integrated Analysis

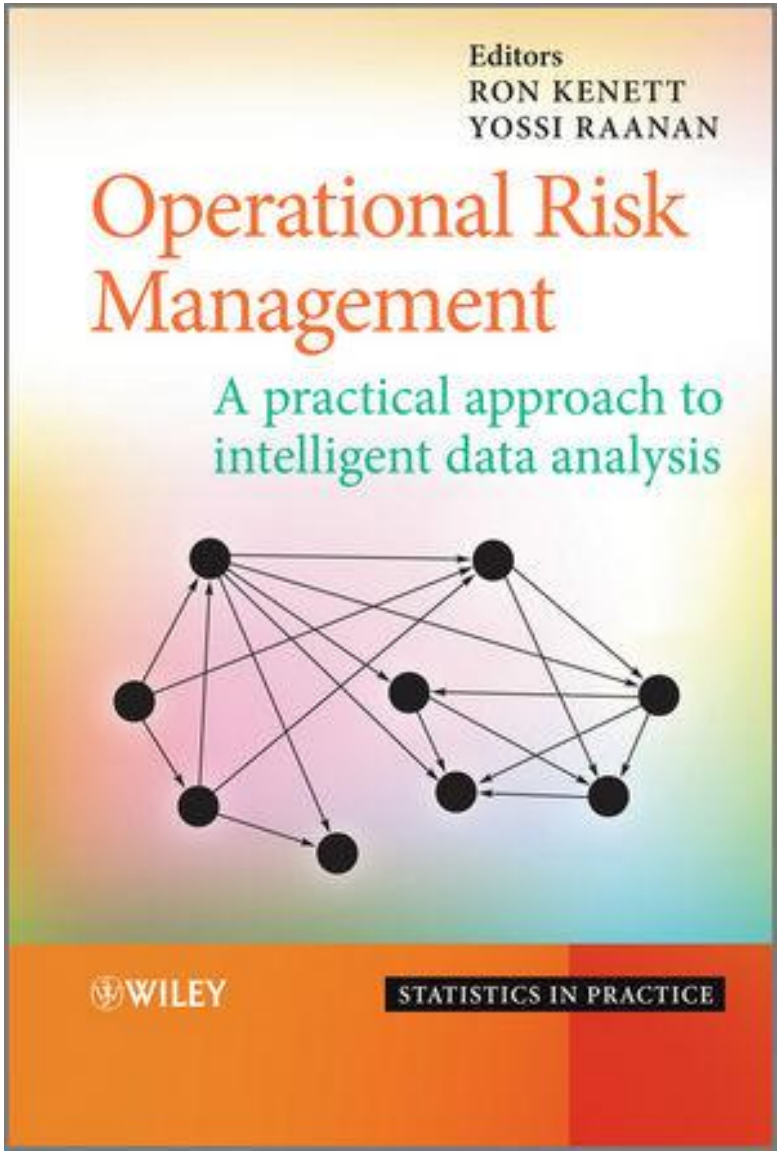
Models / Goals	f_1	f_2	f_3	f_4	….	N_f
g_1	X	X	X	X		4
g_2			X	X		2
g_3		X	X			2
g_4				X		1
N_g	1	2	3	3		

$$InfoQ(f, X, g) = U(f(X|g))$$

Kenett R.S. and Salini S. (2011). Modern Analysis of Customer Surveys: comparison of models and integrated analysis, with discussion, *Applied Stochastic Models in Business and Industry*, 27, pp. 465–475

	Goal	BN	CUB	Rasch	CC
1	**Decide** where to launch improvement initiatives	√	√	√	√
2	**Highlight** drivers of overall satisfaction	√	√	√	
3	**Detect** positive or negative trends in customer satisfaction	√			√
4	**Identify** best practices by comparing products or marketing channels	√	√		√
5	**Determine** strengths and weaknesses	√			√
6	**Set up** improvement goals	√		√	√
7	**Design** a balanced scorecard with customer inputs	√			√
8	**Communicate** the results using graphics	√			√
9	**Assess** the reliability of the questionnaire			√	
10	**Improve** the questionnaire for future use			√	

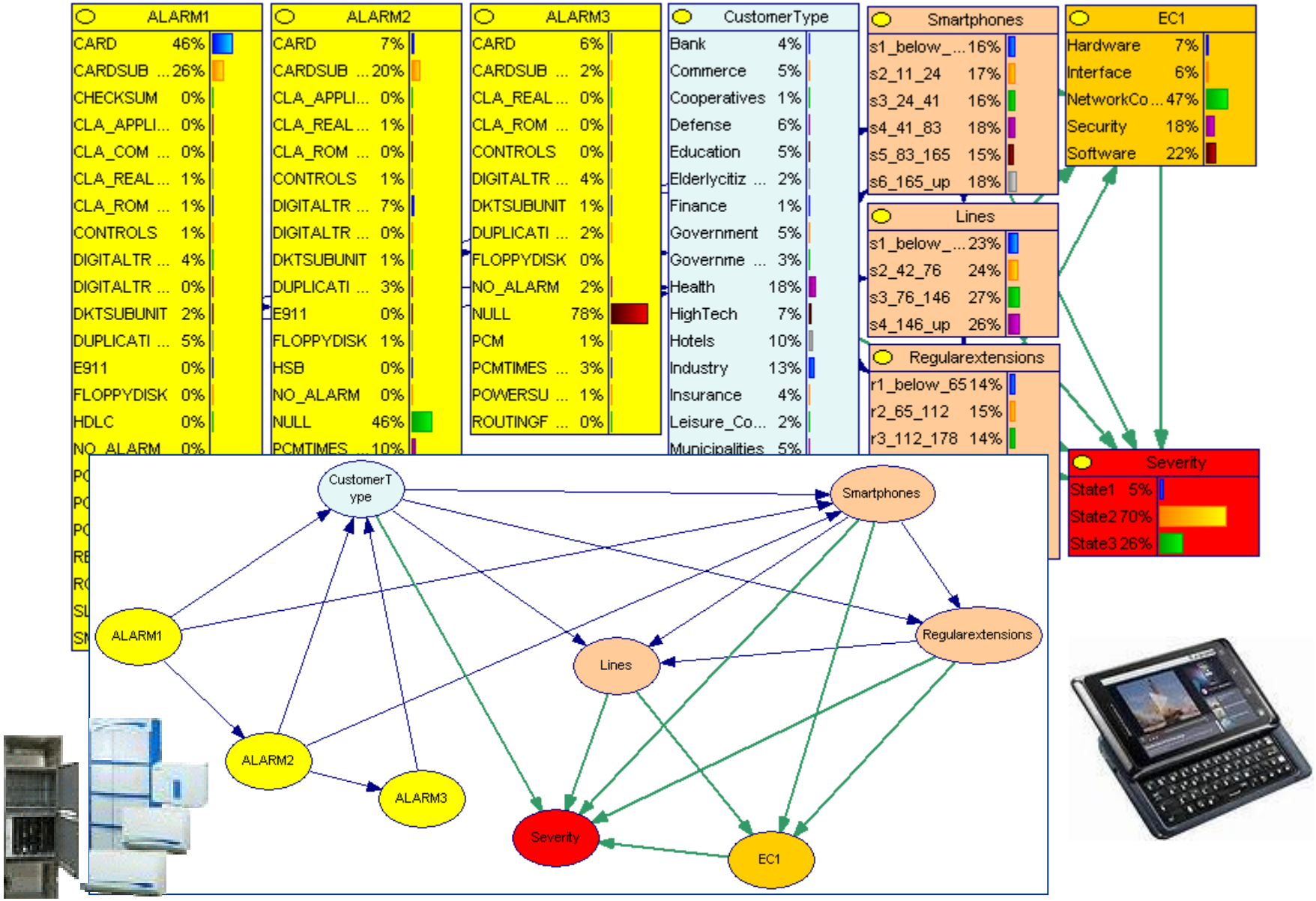
Kenett R.S. and Salini S. (2011). Modern Analysis of Customer Surveys: comparison of models and integrated analysis, with discussion, *Applied Stochastic Models in Business and Industry*, 27, pp. 465–475



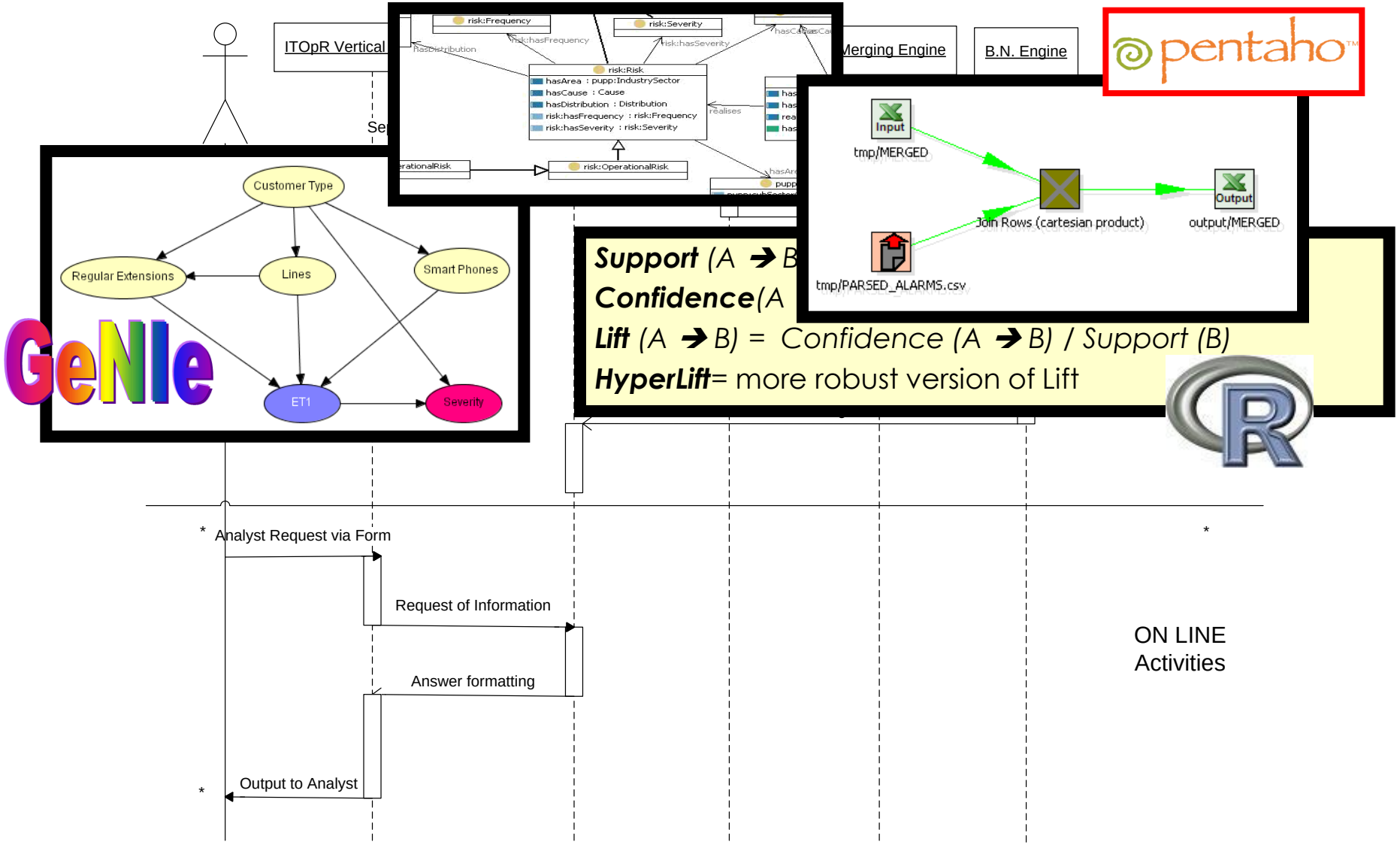
Goal 1: Identify causes of risks that materialized

Goal 2: Design risk mitigation strategies

Goal 3: Provide a risk management dashboard



Bayesian Network of communication network data



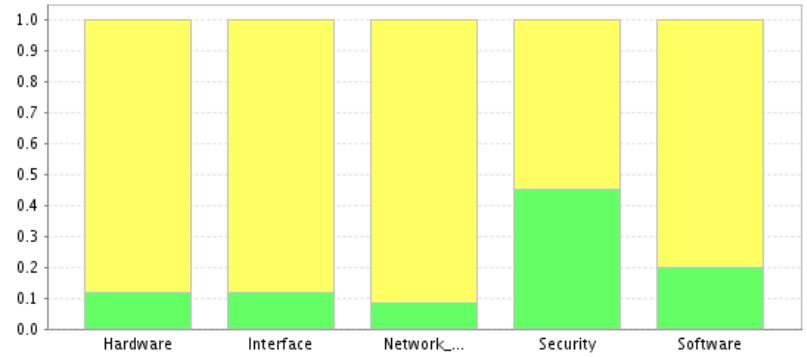
Data structure and data integration

MUSING Project - Pilots - Windows Internet Explorer

http://wins.metaware.it:8380/FormInput/customerAnalysis.html?pbx=92960

MUSING Project - Pilots | Google

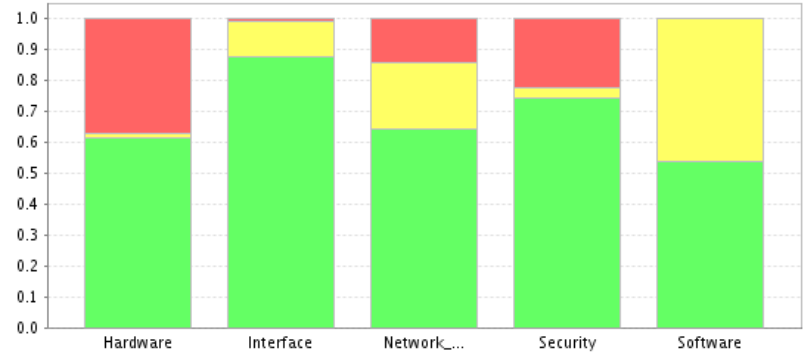
Analysis for customer PBX=92960 (Finance), based on 38 events.



Probability of risks by types and severity

	Hardware	Interface	Network Communications	Security	Software
low	0.120	0.120	0.086	0.450	0.200
medium	0.880	0.880	0.914	0.550	0.800
high	0.000	0.000	0.000	0.000	0.000

Average Stats for same Business Line (Finance)

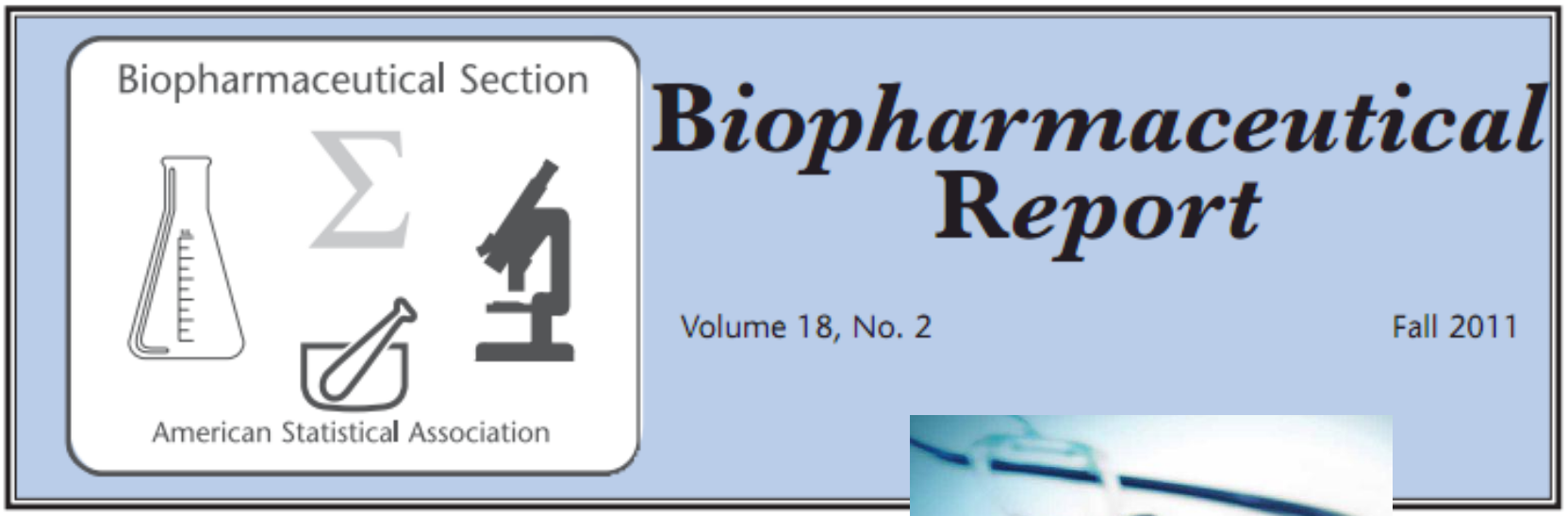


	Hardware	Interface	Network Communications	Security	Software
low	0.614	0.875	0.641	0.741	0.536
medium	0.012	0.117	0.215	0.037	0.464
high	0.373	0.008	0.144	0.222	0.000

Fine | Internet | 100%

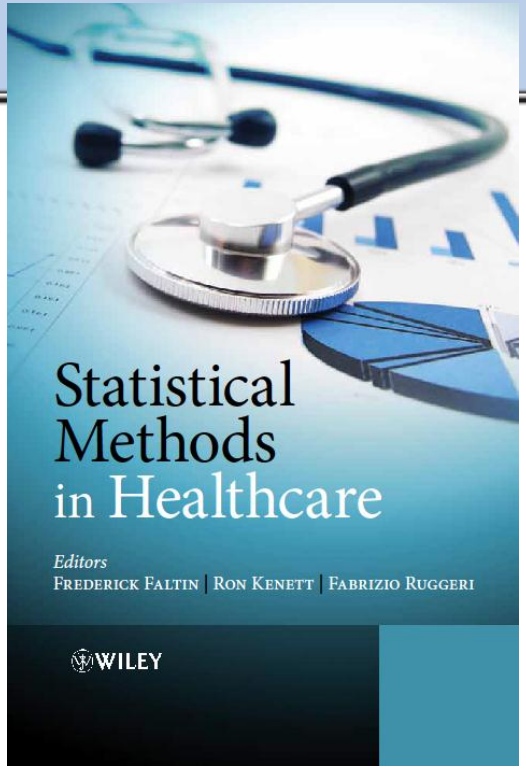
start | Skype™ - paolace... | Posta in arrivo - ... | MUSING Project - ... | Microsoft PowerP... | IT | 9.25

Communication and construct operationalization



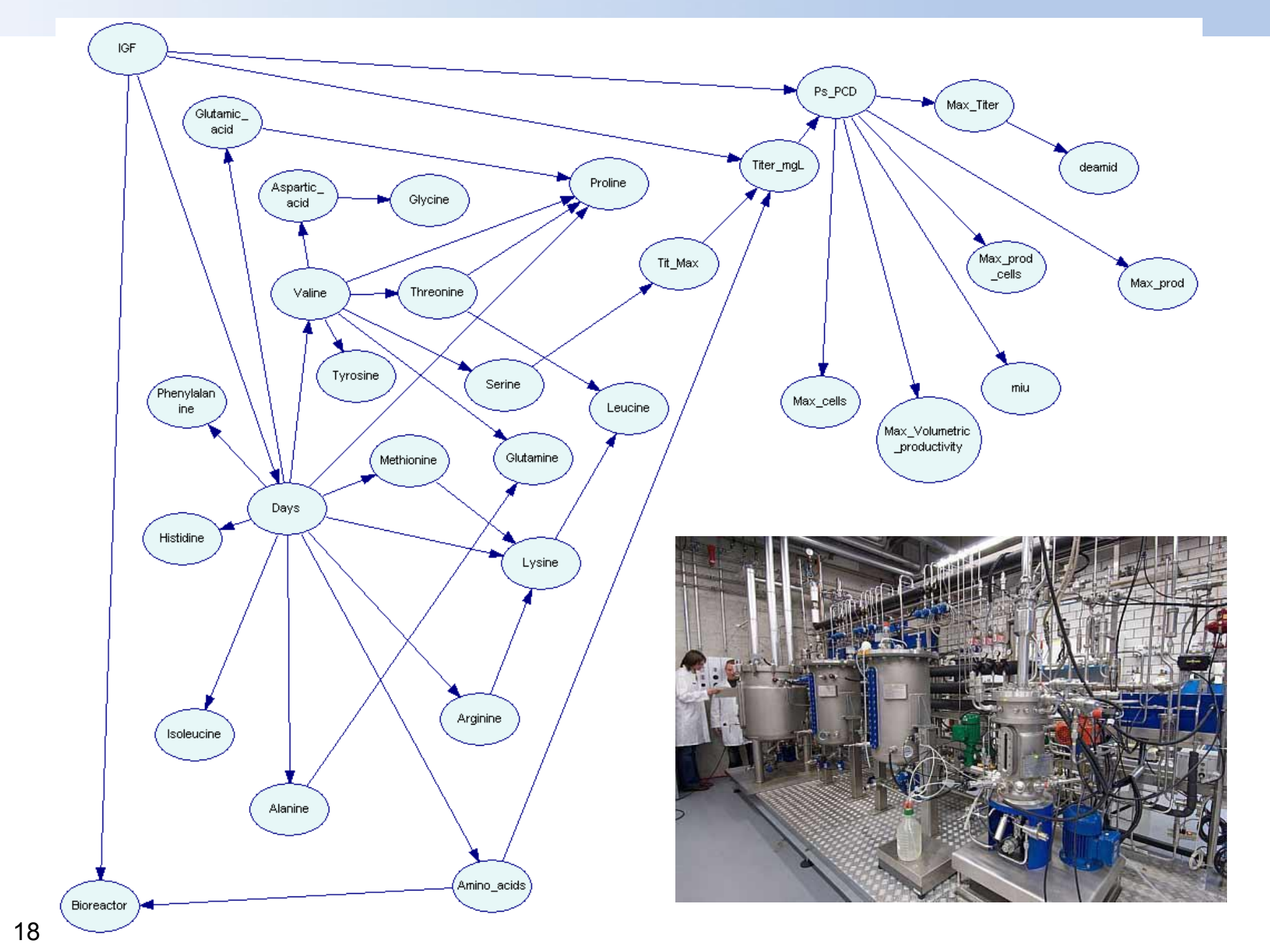
Peterson, J. and Kenett, R.S. (2011), Modelling Opportunities for Statisticians Supporting Quality by Design Efforts for Pharmaceutical Development and Manufacturing, *Biopharmaceutical Report*, ASA Publications, Vol. 18, No. 2, pp. 6-16

Monitoring of bioreactor



Kenett, R.S. (2012). Risk Analysis in Drug Manufacturing and Healthcare, in *Statistical Methods in Healthcare*, Faltin, F., Kenett, R.S. and Ruggeri, F. (editors in chief), John Wiley and Sons.

Managing diabetic patients


IGF
Ps_PCD
Max_Titer
deamid
Glutamic_
acid
Titer_mgL
Proline
Aspartic_
acid
Glycine
Tit_Max
Max_prod
_cells
Max_prod
Valine
Threonine
Tyrosine
Serine
Leucine
miu
Max_cells
Max_Volumetric
_productivity
Phenylalan
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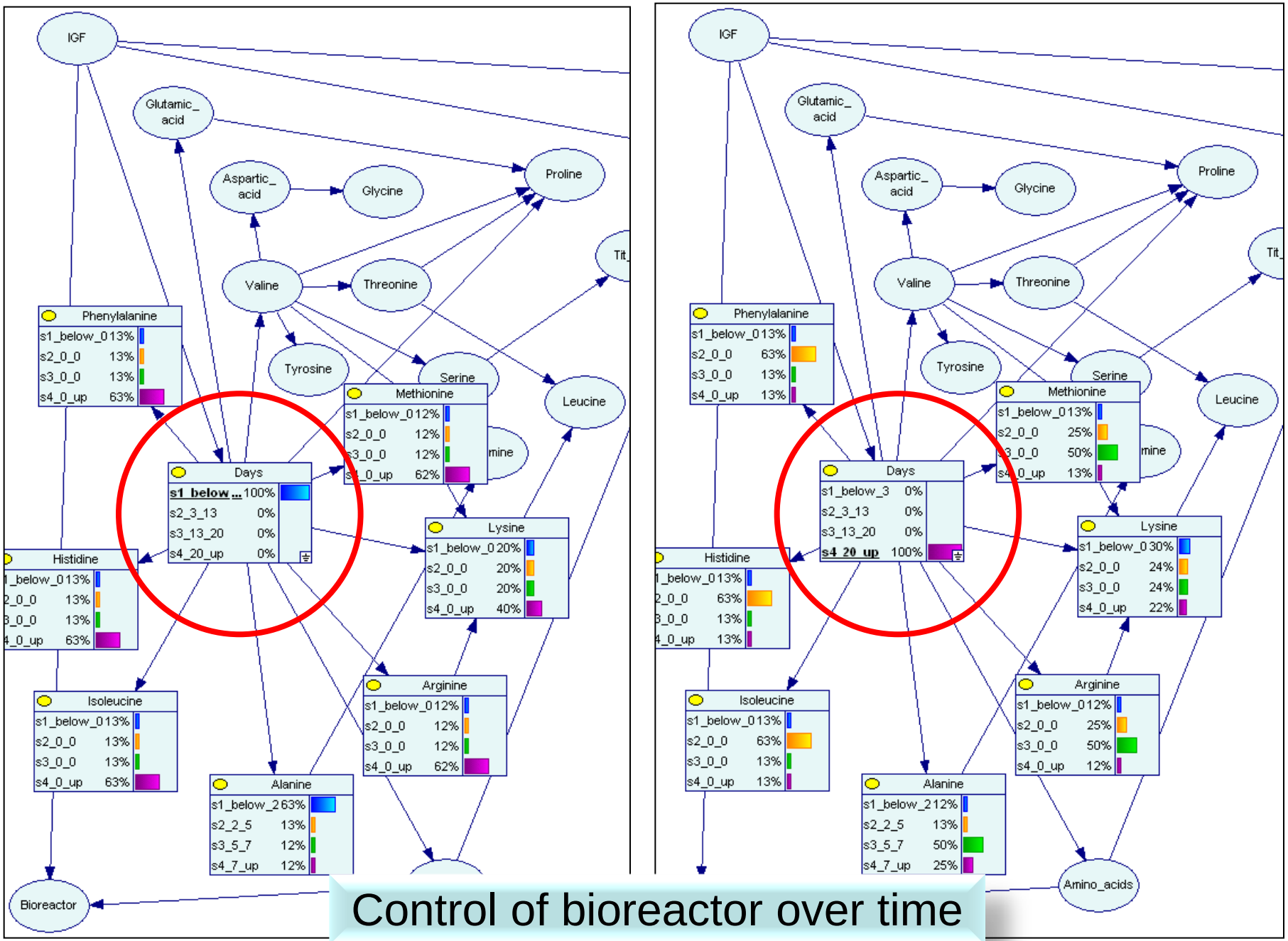
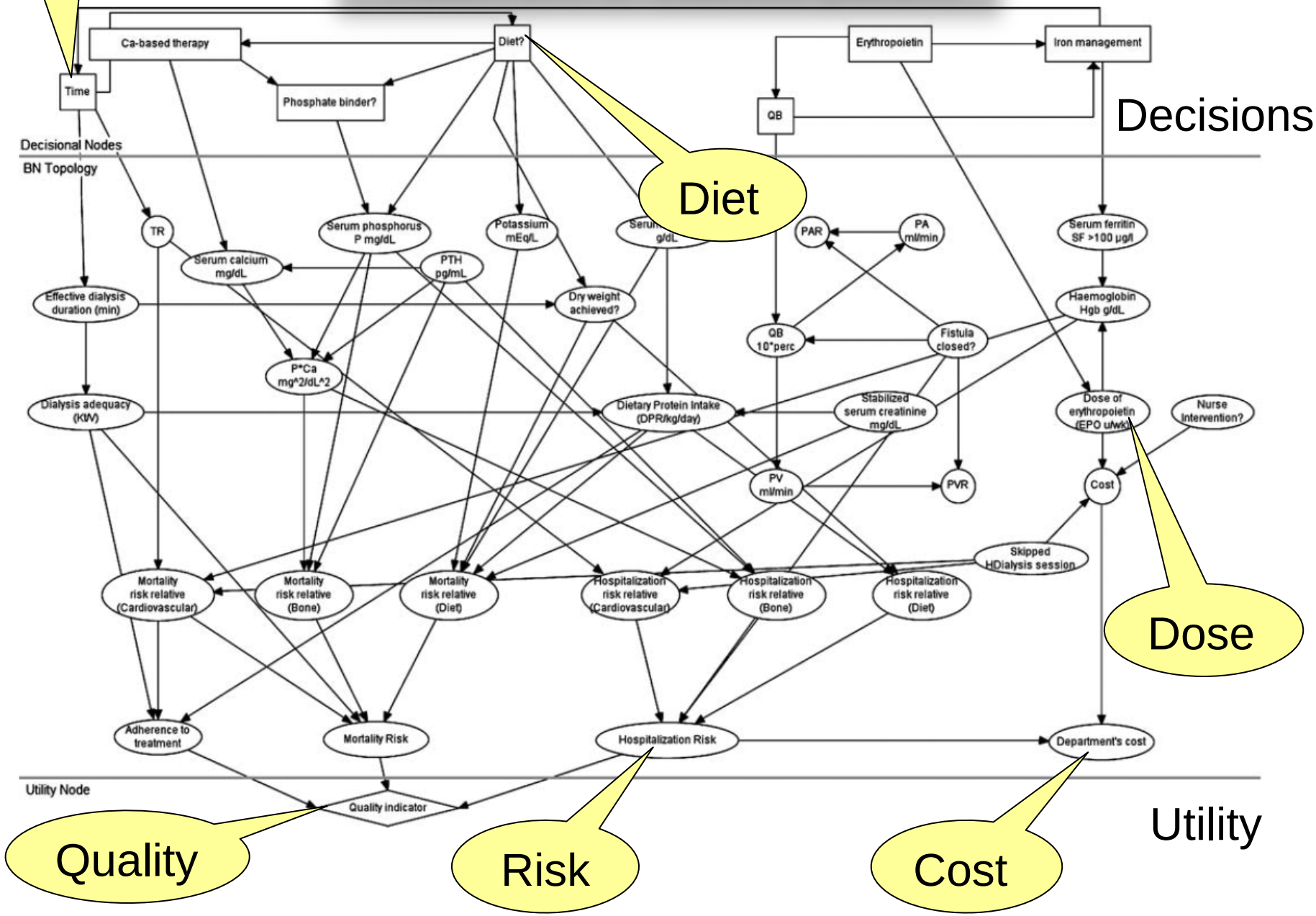
Methionine
Glutamine
Days
Histidine
Lysine
Arginine
Isoleucine
Alanine
Amino_acids
Bioreactor



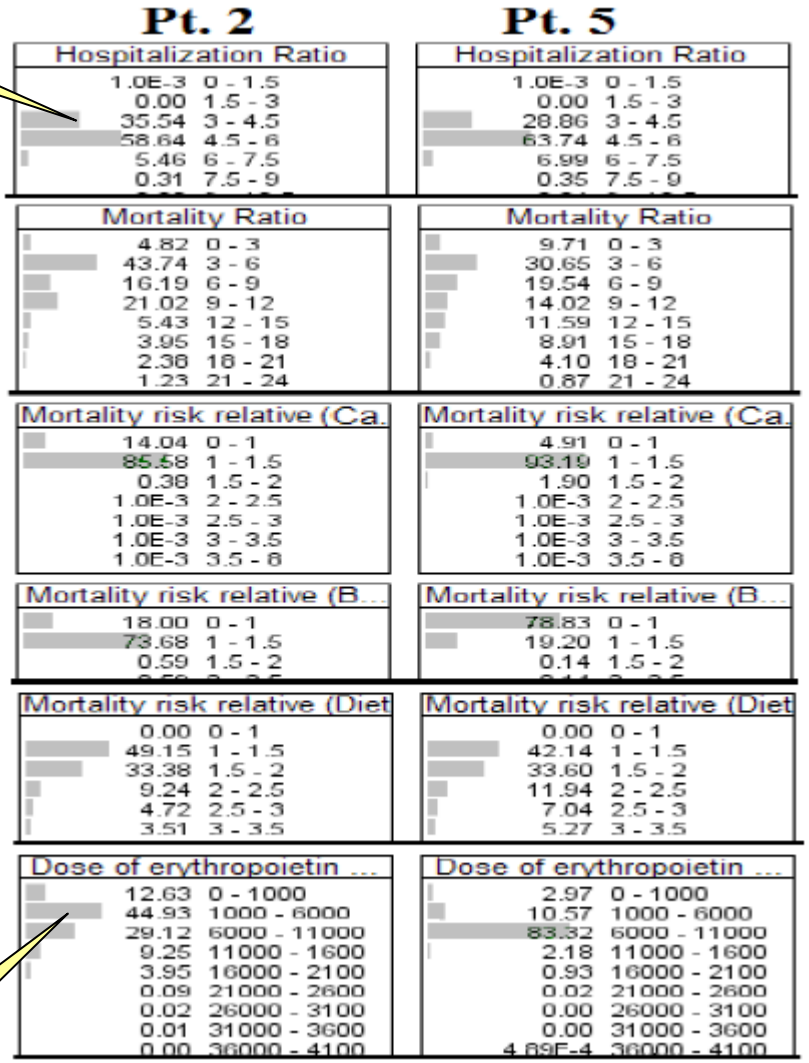
Control of bioreactor over time

Treatment of diabetic patient



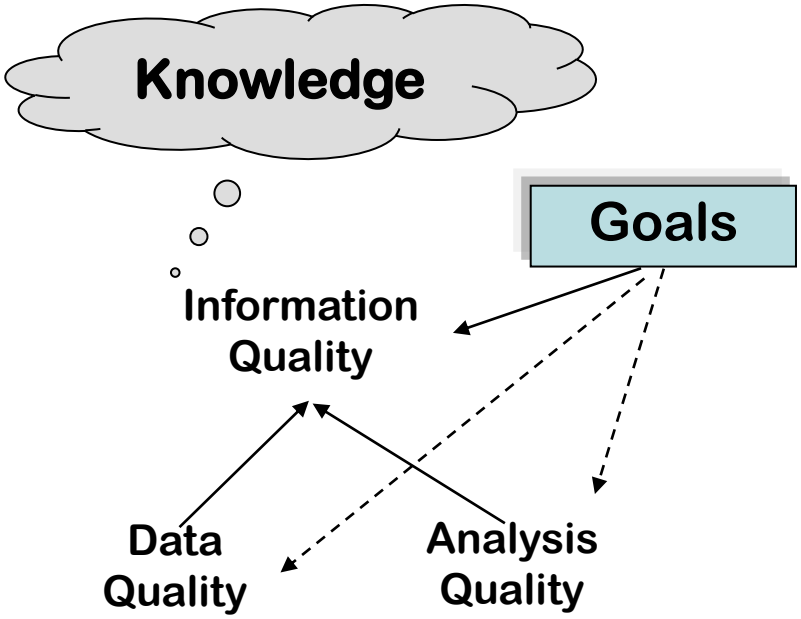
Risk

Decision	State of Actions
Ca-based Therapy	* Treat hypercalcemia; * Continue current therapy; * Decrease vitamin D dose to achieve ideal Ca; Decrease Ca-based . . . * Decrease or discontinue vitamin D dose or Ca-based phosphate binders; . . .
Phosphate binder?	* Assess nutrition, discontinue phosphate binder if . . . * Being dietary counseling and restrict dietary phosphate; start or increase . . . * Being short-term Al-based phosphate binder use, then increase . . .
QB	* Increase QB; * Keep QB; * Decrease QB.
Erythro-poietin	* Keep the current dose; . . .
Iron Management	* Keep the treatment; . . .
Time	. . .
Diet?	. . .



Dose

InfoQ and BN



1. Data resolution
2. Data structure
3. Data integration
4. Temporal relevance
5. Chronology of data and goal
6. Generalizability
7. Construct operationalization
8. Communication

$$InfoQ(f,X,g) = U(f(X|g))$$