ETSN15 - Requirements Engineering

Lecture 5:

Market-Driven Requirements Engineering [MDRE]

[INTDEP]

Release Planning [RP]

Preparations for Lab 2

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Market-Driven Requirements Engineering (MDRE)

Book chapter [MDRE] in compendium

- Market-Driven Requirements Engineering for Software Products
- Regnell, B., & Brinkkemper, S.
- Engineering and Managing Software Requirements, Eds. A. Aurum and C. Wohlin, Springer, ISBN 3-540-25043-3, 2005

Characteristics of MDRE

- Success through sales and market share
  - (not just customer satisfaction)
- Release Planning focus on
  - Time-to-market
  - Multiple release
- Continuous evolution
  - (not just maintenance)
- Inventing requirements + market analysis
  - (not just collecting 1-on-1)
- Stakeholders
  - Market segments with potential customers
  - Competitors (confidentiality often needed)
- Continuous inflow of requirements

[MDRE]

Decisions outcomes in MDRE

		Decision	
		Selected	*Rejected*
Requirements Quality	*alfa*	*A* Correct selection ratio	*B* Incorrect selection ratio
	beta	*C* Incorrect selection ratio	*D* Correct selection ratio

Product Quality: $Q_p = A/(A+C)$

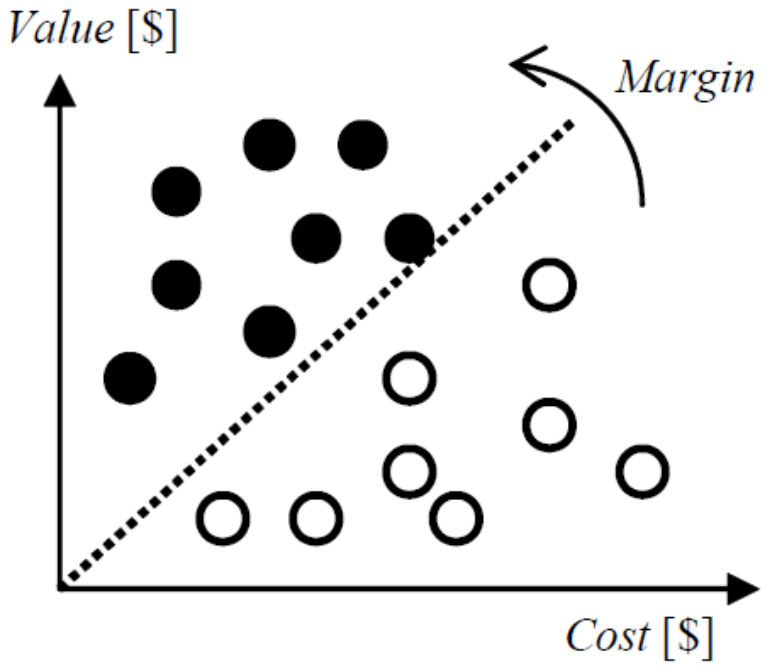
Decision Quality: $Q_d = (A+D)/(A+B+C+D)$

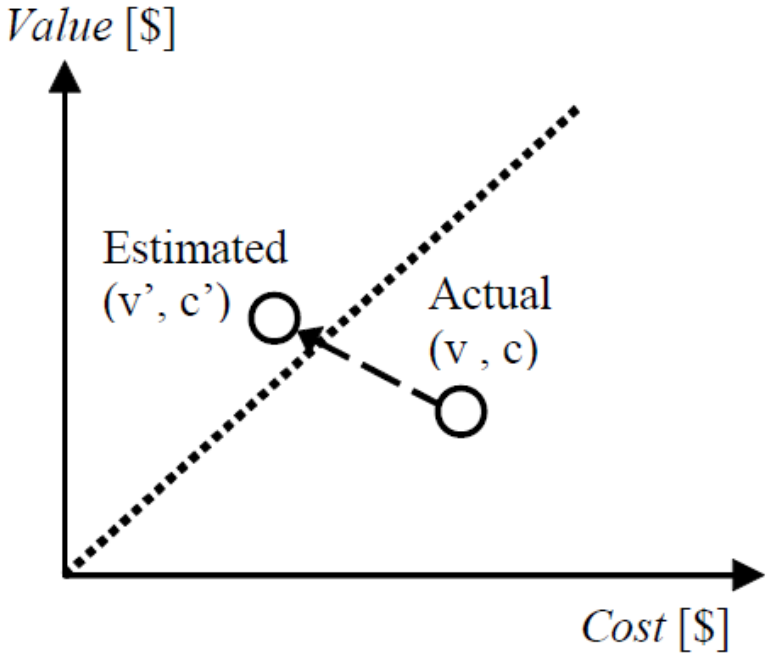
[MDRE]

Finding the golden grains despite uncertain cost-value estimates

Figure 13.1 (a) Cost-Value Diagram with alfa-requirements (filled) and beta-requirements (empty).

Figure 13.1 (b) Estimated values are differing from actual values causing wrong selection decision.



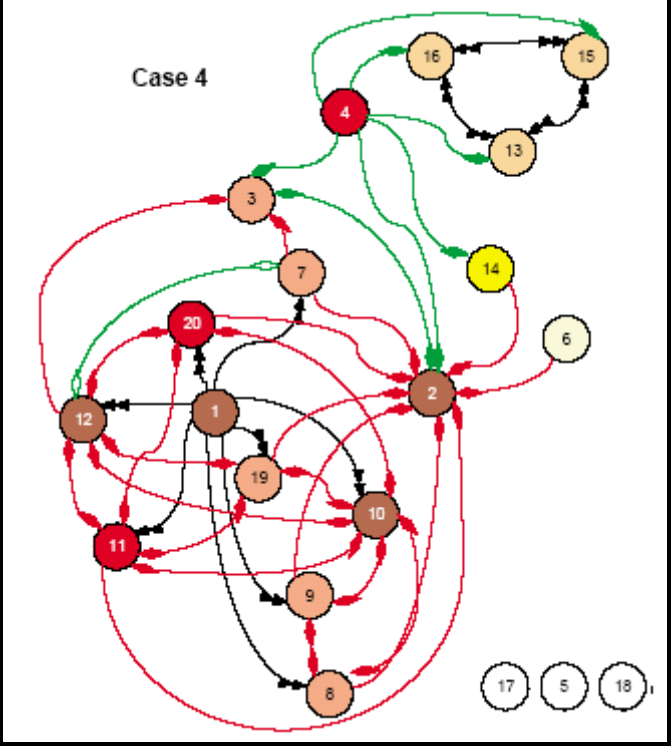


[MDRE]

Some inter-related **challenges** in MDRE

- Requirements **inter-dependency** management
- Requirements **prioritization**
- **Release planning**
  - Balancing market pull and technology push
  - Chasm between marketing and development
  - Cost-value-estimation (over- & under-est.)
  - Overloaded requirements management

[INTDEP] in compendium



An industrial survey of requirements interdependencies in software product release planning

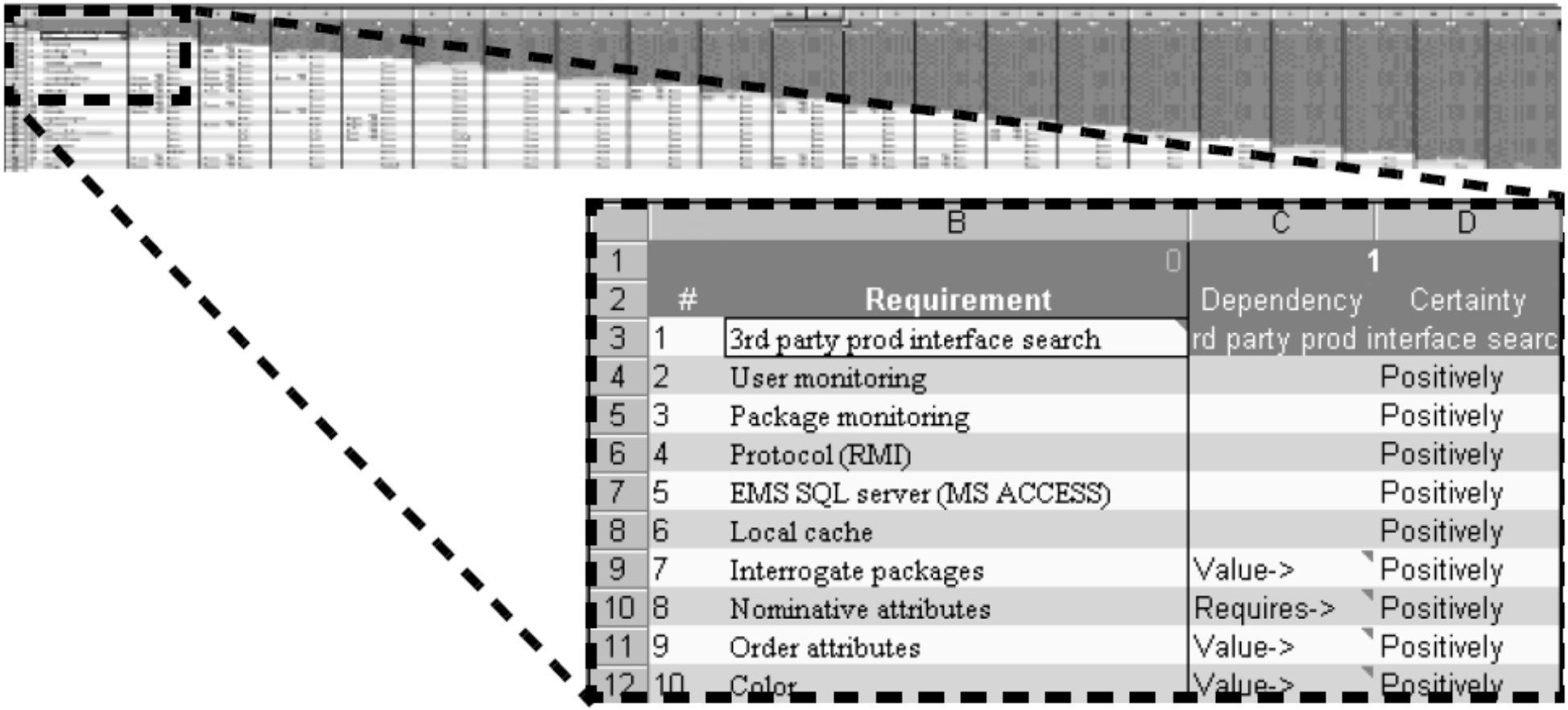
Carlshamre, P., Sandahl, K., Lindvall, M., Regnell, B., Natt och Dag, J.

IEEE Int. Conf. on Requirements Engineering (RE01), Toronto, Canada, pp. 84–91 (2001)

Research Method

- survey of five different companies
- a manager of a product/project was asked to identify and classify interdependencies among 20 high priority requirements.

Data collection



	B	C	D
1	0		1
2	# Requirement	Dependency	Certainty
3	1 3rd party prod interface search	rd party prod interface searc	
4	2 User monitoring		Positively
5	3 Package monitoring		Positively
6	4 Protocol (RMI)		Positively
7	5 EMS SQL server (MS ACCESS)		Positively
8	6 Local cache		Positively
9	7 Interrogate packages	Value->	Positively
10	8 Nominative attributes	Requires->	Positively
11	9 Order attributes	Value->	Positively
12	10 Color	Value->	Positively

Figure 1. The spreadsheet designed for pairwise assessment of 20 requirements.

Different types of interdependencies

Table 2. Preliminary set of interdependencies.

Priority	Type	Meaning
1	R_1 AND R_2	R_1 requires R_2 to function, and R_2 requires R_1 to function.
2	R_1 REQUIRES R_2	R_1 requires R_2 to function, but not vice versa.
3	R_1 TEMPORAL R_2	Either R_1 has to be implemented before R_2 or vice versa.
4	R_1 CVALUE R_2	R_1 affects the value of R_2 for a customer. Value can be either positive or negative.
4	R_1 ICOST R_2	R_1 affects the cost of implementing R_2. Value can be either positive or negative.
5	R_1 OR R_2	Only one of $\{R_1, R_2\}$ needs to be implemented.

Examples:

AND. A printer requires a driver to function, and the driver requires a printer to function.

REQUIRES. Sending an e-mail requires a network connection, but not the opposite.

TEMPORAL. The function *Add object* should be implemented before *Delete object*. (This type is doubtful, which is discussed in section 3.1)

CVALUE. A detailed on-line manual may decrease the customer value of a printed manual.

ICOST. A requirement stating that “no response time should be longer than 1 second” will typically increase the cost of implementing many other requirements.

OR. In a word processor, the capability to create pictures in a document can either be provided as an integrated drawing module or by means of a link to an external drawing application.

Expressing interdependencies in reqT

- An AND relation is equivalent to two mutual requires-relations:

```
Feature("printerX1") requires Feature("driverX")
Feature("driverX") requires Feature("printerX1")
```

- A requires relation can be non-mutual :

```
Feature("sendEmail") requires Feature("networkAccess")
```

- Temporal relations regarding a preferred implementation order can be expressed using precedes:

```
Function("add") precedes Function("delete")
```

- Exclusion (xor) can be expressed by an excludes relation (only one is needed as exclusion is mutual):

```
Design("centralized") excludes Design("distributed")
Design("distributed") excludes Design("centralized")
```

- Entities that support or hinder each other can be modeled using hurts and helps relations :

```
Goal("secure") helps Goal("safe")
Goal("secure") hurts Goal("simple")
```

[Some examples modified from Carlshamre, P., Sandahl, K., Lindvall, M., Regnell, B., Natt och Dag: "An industrial survey of requirements interdependencies in software product release planning", J.: *Int. Conf. on Requirements Engineering (RE01)*, Toronto, Canada, pp. 84–91, 2001]

Expressing CVALUE dependencies as Constraints in reqT

```
val m = Model(
          Req("x") has (Order(1), Benefit(100)),
          Req("y") has Order(1))  // Same release
val c = Constraints(
     Req("y")/Benefit :: {0 to 1000},
     Sum(Req("x")/Benefit, Req("y")/Benefit) === Var("SumXY"),
     Var("SumXY") :: {0 to 2000},
     IfThenElse(
       Req("x")/Order === Req("y")/Order, //If same release
       Var("SumXY") === 400,              //then more valuable
       Var("SumXY") === 200               //else less valuable
     ))

val m2 = (m + c).satisfy
```

```
m2: reqT.Model =
Model(
  Req("y") has (Benefit(300), Order(1)),
  Req("x") has (Order(1), Benefit(100)),
  Constraints(
    Var("SumXY") === 400))
```

Expressing CVALUE dependencies as Constraints in reqT

```
val m = Model(
          Req("x") has (Order(1), Benefit(100)),
          Req("y") has Order(2))  // Different releases
val c = Constraints(
     Req("y")/Benefit :: {0 to 1000},
     Sum(Req("x")/Benefit, Req("y")/Benefit) === Var("SumXY"),
     Var("SumXY") :: {0 to 2000},
     IfThenElse(
       Req("x")/Order === Req("y")/Order, //If same release
       Var("SumXY") === 400,              //then more valuable
       Var("SumXY") === 200               //else less valuable
     ))

val m2 = (m + c).satisfy
```

```
m2: reqT.Model =
Model(
  Req("y") has (Benefit(100), Order(2)),
  Req("x") has (Order(1), Benefit(100)),
  Constraints(
    Var("SumXY") === 200))
```

Not always straight forward …

- "*if R2 is completely worthless to the customer without R1, and we would thus never do R2 without R1, do we classify the relationship as REQUIRED or just CVALUE?*"
- REQUIRES sometimes arises from the opposite reasoning: "If we do R2, then we can do R1 too!", which implies that the direction of the relationship could be the opposite; could e.g. be called "ENABLES" or "**HELPS**"

Summary of identified interdependencies

Table 2. Summary of identified interdependencies.

	# dependencies	most common type	# singular req's	10% of the req's are responsible for	20% of the req's are responsible for	coupling (cf. section 3.5)
Case 1 (prod.)	19	ICOST 79%	4	47% of distinct interdep's	79% of distinct interdep's	10%
Case 2 (prod.)	29	CVALUE 45%	3	55% of distinct interdep's	76% of distinct interdep's	15%
Case 3 (prod.)	42	ICOST 86%	3	50% of distinct interdep's	74% of distinct interdep's	22%
Case 4 (besp.)	41	AND 41%	3	44% of distinct interdep's	71% of distinct interdep's	22%
Case 5 (besp.)	24	REQUIRES 79%	4	42% of distinct interdep's	67% of distinct interdep's	13%

1. 10% of the requirements are responsible for roughly 50% of the interdependencies
2. 20% of the requirements are responsible for roughly 75% of all interdependencies
3. About 20% of the requirements are singular
4. Customer-specific: more functionality-related ; Market-driven: more value-related dependencies

Example of dependency structures

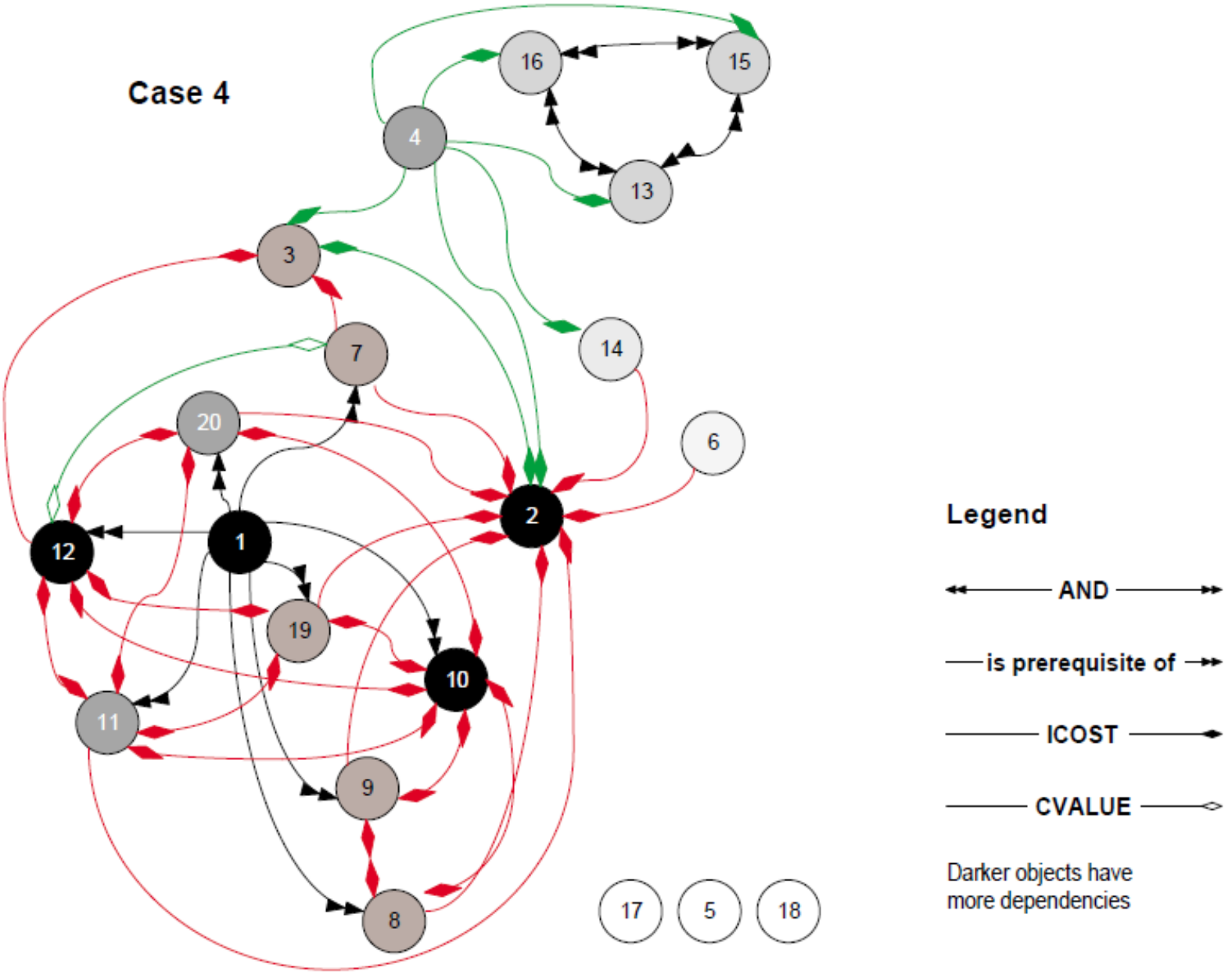


Figure 2. Visualization of requirements interdependecies for one of the five cases.

Coupling measures

$$Creq = \frac{I}{(R(R-1))/2}$$

I =#dependencies
R =#requriements

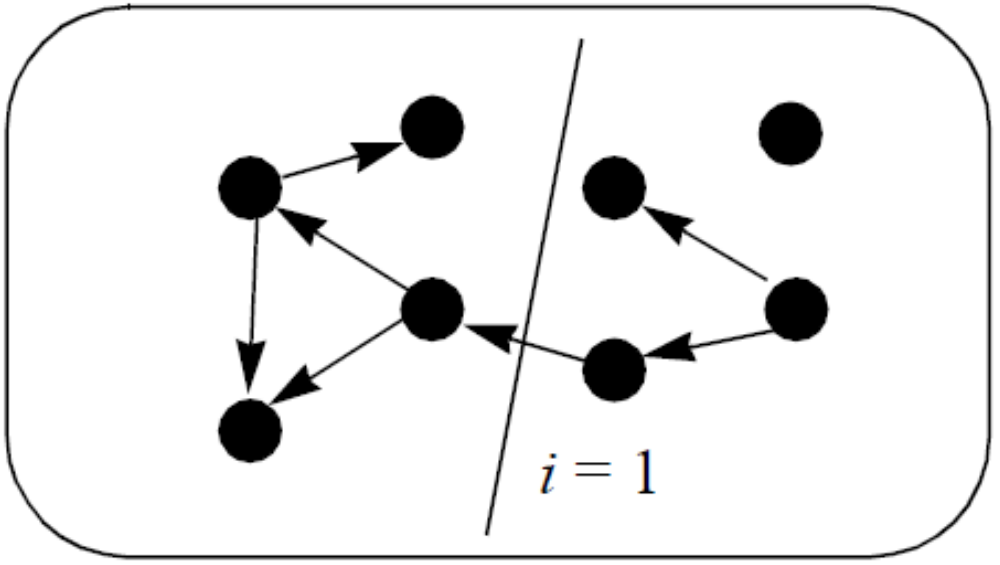
In survey:
10-22%

Release coupling:

$$Crel = \frac{i}{I}$$

i = #dep. betw. 2 partitions

Figure 3. Example illustrating the concepts of require-ments and release coupling.



$R = 8$
$I = 7$

$$Creq = \frac{7}{28}$$

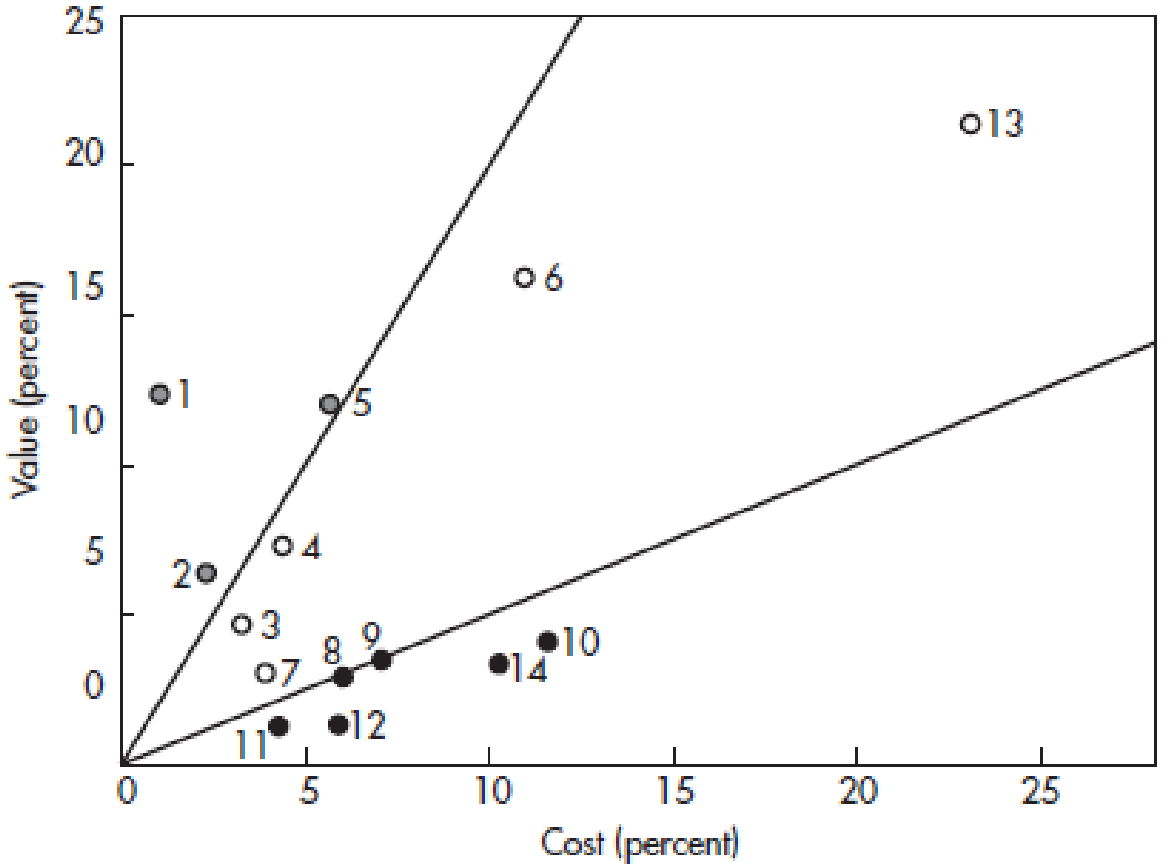
$$Crel = \frac{1}{7}$$

Requirements Prioritization (summary from week 1)

Book chapter [PRIO] in compendium

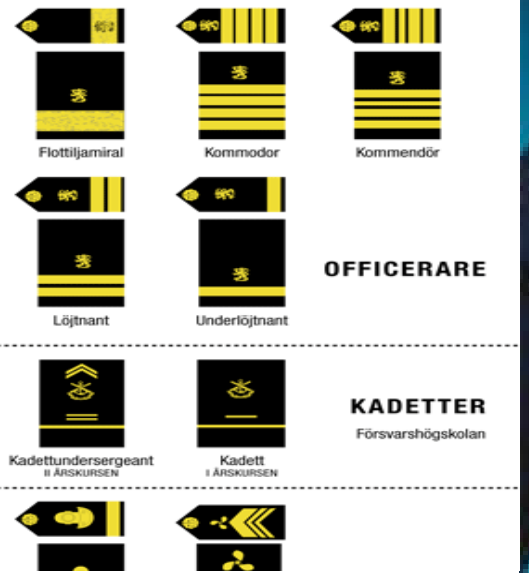
- Requirements prioritization
- Berander, P., & Andrews, A.
- Engineering and Managing Software Requirements, Eds. A. Aurum and C. Wohlin, Springer, ISBN 3-540-25043-3, 2005

Filtering requirements



Karlsson, Joachim, and Kevin Ryan. "A cost-value approach for prioritizing requirements." *IEEE software* 14.5 (1997): 67-74.

Prioritization scales



Categorization

e.g.: must, ambiguous, volatile

Partition in groups without greater-less relations

Ordinal scale

e.g.: more expensive, higher risk, higher value

Ranked list
A>B

Ratio scale

ex: $, h,

% (relative)

Numeric relations:
A=2*B

[PRIO]

Prioritization techniques

- Grouping, numbering assignment (grading)
- Ranking (sorting)
- Top-ten (or Top-n)
- Analytical Hierarchy Process (AHP)
- 100$ test
- Combination of techniques

On Lab 1 you used:

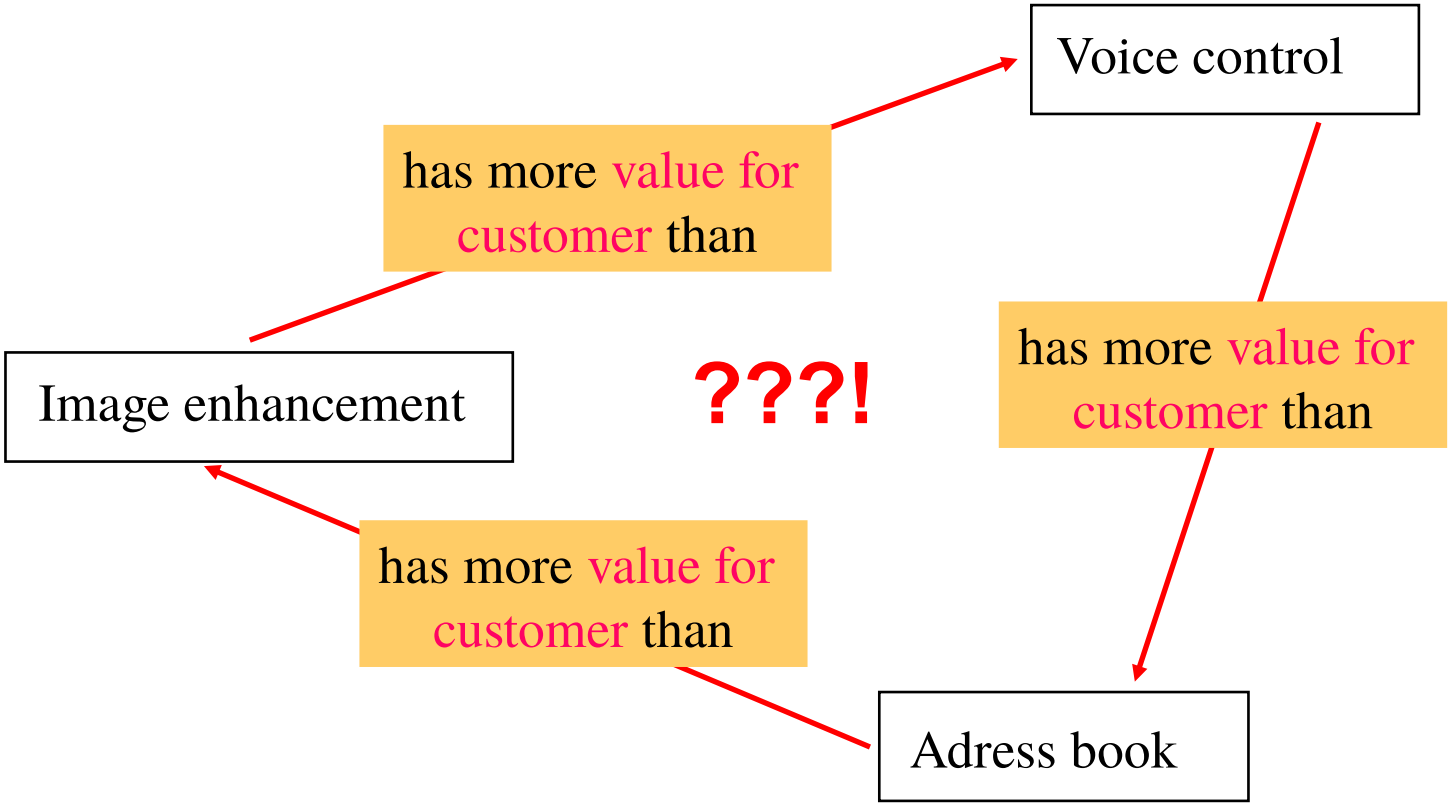
- ordinal-scale prio with sorting by pair-wise comparisons and
- ratio-scale prio with the 100$ test

One (simplistic) approach to manage interdependencies:

- grouping

[PRIO]

Tools can help find inconsistencies



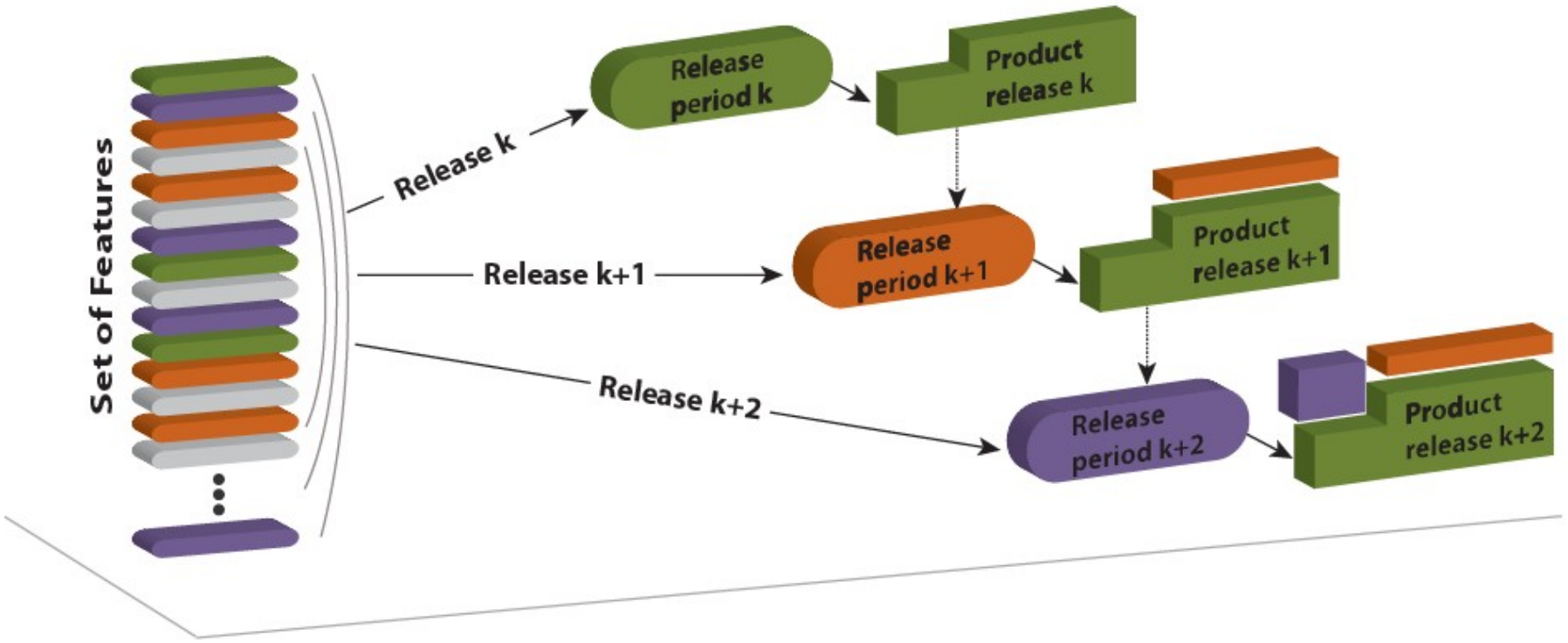
[PRIO]

Release Planning

Paper [RP] in compendium

- The art and science of software release planning
- Ruhe, G., & Saliu, M. O.
- IEEE software, 22(6), 47-53. 2005

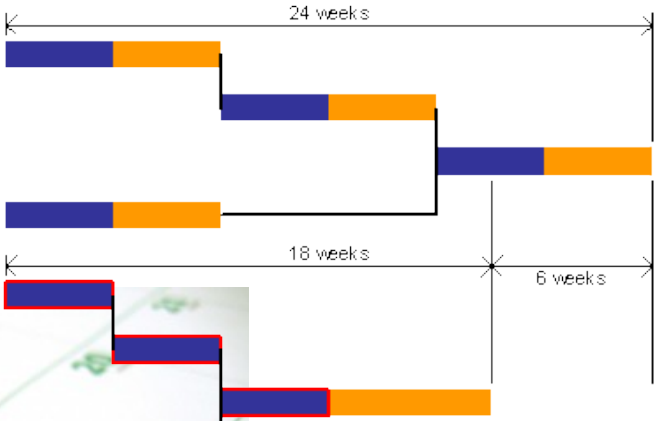
What is Release Planning?



[RP]

Release Planning involves...

- ...prioritization + scheduling under various constraints, e.g., resource and precedence constraints



[RP]

Example planning parameters

- Requirements priorities (from prioritization)
- Available resources
- Delivery time
- Requirements interdependencies
  - Precedence, Coupling, Excludes
- System architecture
- Dependencies to the code base

[RP]

What is a good release plan?

- A good release plan should
  - Provide maximum business value by
    - offering the best possible blend of features
    - in the right sequence of releases
  - satisfy the most important stakeholders involved
  - be feasible with available resources, and
  - Reflect existing dependencies between features

[RP]

Baseline: Release Planning - on the fly

- Informal process
- Rationale behind decisions not always clear
- Constraints regarding e.g., resources and stakeholders not systematically taken into account
- Already in case of 20 features and 3 releases

  4^{20} > 1.000.000.000.000 = 10^{12} possibilities


```
reqT> val big = BigInt(4).pow(20)
big: scala.math.BigInt = 1099511627776
```

[RP]

Investigate with reqT why greedy is not good

```
val m = Model(
  Feature("a") has (Benefit(90), Cost(100)),
  Feature("b") has (Benefit(85), Cost(90)),
  Feature("c") has (Benefit(80), Cost(25)),
  Feature("d") has (Benefit(75), Cost(23)),
  Feature("e") has (Benefit(70), Cost(22)),
  Feature("f") has (Benefit(65), Cost(20)),
  Feature("g") has (Benefit(60), Cost(10)),
  Feature("h") has (Benefit(55), Cost(30)),
  Feature("i") has (Benefit(50), Cost(30)),
  Feature("j") has (Benefit(45), Cost(30)),
  Release("r1") has Capacity(100),
  Release("r2") has Capacity(90))
```

```
def plan(input: Model,
      pickNext: (Model,Release)=>Option[Feature]): Model = {
  var result = input
  releases(input).foreach { r =>
    var next = pickNext(result, r)
    while (next.isDefined) {
      result = allocate(result, next.get, r)
      next = pickNext(result, r)
    }
  }
  result
}

plan(m, random)
plan(m, greedy)
```

```
def features(m: Model): Vector[Feature] = m.tip.collect{case f: Feature => f}
def releases(m: Model): Vector[Release] = m.tip.collect{case r: Release => r}
def allocate(m: Model, f: Feature, r: Release): Model = m + (r has f)
def isAllocated(m: Model, f: Feature): Boolean = releases(m).exists(r => (m/r).contains(f))
def allocatedCost(m: Model, r: Release): Int = (m/r).entities.collect{case f => m/f/Cost}.sum
def isRoom(m: Model, f: Feature, r: Release): Boolean = m/r/Capacity >= allocatedCost(m,r) + m/f/Cost
def featuresInGreedyOrder(m: Model): Vector[Feature] = features(m).sortBy(f => m/f/Benefit).reverse

def random(m: Model, r: Release): Option[Feature] = scala.util.Random.shuffle(features(m)).
  filter(f => !isAllocated(m,f) && isRoom(m,f,r)).headOption

def greedy(m: Model, r: Release): Option[Feature] =
  featuresInGreedyOrder(m).find(f => !isAllocated(m,f) && isRoom(m,f,r))
```

Optimal vs. Greedy

```
val optimal = Model(
  Feature("a") has (Benefit(90), Cost(100)),
  Feature("b") has (Benefit(85), Cost(90)),
  Feature("c") has (Benefit(80), Cost(25)),
  Feature("d") has (Benefit(75), Cost(23)),
  Feature("e") has (Benefit(70), Cost(22)),
  Feature("f") has (Benefit(65), Cost(20)),
  Feature("g") has (Benefit(60), Cost(10)),
  Feature("h") has (Benefit(55), Cost(30)),
  Feature("i") has (Benefit(50), Cost(30)),
  Feature("j") has (Benefit(45), Cost(30)),
  Release("r1") has (Capacity(100), Feature("c"), Feature("d"), Feature("e"), Feature("f"),
    Feature("g")),
  Release("r2") has (Capacity(90), Feature("h"), Feature("i"), Feature("j")))
```

```
def sumAllocatedBenefit(m: Model) =
  releases(m).map(r => (m/r).collect{case f: Feature => m/f/Benefit}.sum).sum

val beneftitOptimal = sumAllocatedBenefit(optimal)
val benefitGreedy   = sumAllocatedBenefit(plan(m,greedy))
val ratio = benefitGreedy.toDouble / beneftitOptimal
```

Example from [RP]

Table 1

Features, resource consumption, and stakeholder feature evaluations

Feature $f(i)$	Resources				Stakeholder $S(1)$		Stakeholder $S(2)$	
	Analyst & designers (hrs) $r(i,1)$	Developers (hrs) $r(i,2)$	QA (hrs) $r(i,3)$	Budget (US$ in thousands) $r(i,4)$	Value value(1,i)	Urgency urgency(1,i)	Value value(2,i)	Urgency urgency(2,i)
1. Cost reduction of transceiver	150	120	20	1,000	6	(5, 4, 0)	2	(0, 3, 6)
2. Expand memory on BTS controller	75	10	8	200	7	(5, 0, 4)	5	(9, 0, 0)
3. FCC out-of-band emissions	400	100	20	200	9	(9, 0, 0)	3	(2, 7, 0)
4. Software quality initiative	450	100	40	0	5	(2, 7, 0)	7	(7, 2, 0)
5. USEast Inc., Feature 1	100	500	40	0	3	(7, 2, 0)	2	(9, 0, 0)
6. USEast Inc., Feature 2	200	400	25	25	9	(7, 2, 0)	3	(5, 4, 0)
7. China Feature 1	50	250	20	500	5	(9, 0, 0)	3	(2, 7, 0)
8. China Feature 2	60	120	19	200	7	(8, 1, 0)	1	(0, 0, 9)
9. 12-carrier BTS for China	280	150	40	1,500	6	(9, 0, 0)	5	(0, 8, 1)
10. Pole-mount packaging	200	300	40	500	2	(5, 4, 0)	1	(0, 0, 9)
11. Next-generation BTS	250	375	50	150	1	(8, 1, 0)	5	(0, 7, 2)
12. India BTS variant	100	300	25	50	3	(9, 0, 0)	7	(0, 6, 3)
13. Common feature 01	100	250	20	50	7	(9, 0, 0)	9	(9, 0, 0)
14. Common feature 02	0	100	15	0	8	(9, 0, 0)	3	(6, 3, 0)
15. Common feature 03	200	150	10	0	1	(0, 0, 9)	5	(3, 6, 0)
Total resource consumption	2,615	3,225	392	4,375				
Available capacity, Release 1	1,300	1,450	158	2,200				
Available capacity, Release 2	1,046	1,300	65	1,750				

Example from [RP]

WAS: weighted average satisfaction of stakeholder priorities

Table 2

Two qualified release plan alternatives, listing the release to which each feature is assigned and each weighted average satisfaction

	Release Plan x1		Release Plan x2	
Feature $f(i)$	$x1(i)$	WAS(i,k)	$x2(i)$	WAS(i,k)
1. Cost reduction of transceiver	1	84.0	1	84.0
2. Expand memory on BTS controller	1	287.0	1	287.0
3. FCC out-of-band emissions	1	252.0	3	0.0
4. Software quality initiative	3	0.0	1	233.8
5. USEast, feature 1	1	134.4	3	0.0
6. USEast, feature 2	2	516.6	3	0.0
7. China feature 1	2	277.2	1	88.2
8. China feature 2	2	43.2	1	19.6
9. 12-carrier BTS for China	3	0.0	2	72.0
10. Pole-mount packaging	3	0.0	3	0.0
11. Next-generation BTS	3	0.0	3	0.0
12. India BTS variant	3	0.0	2	75.6
13. Common feature 01	1	37.8	1	516.6
14. Common feature 02	1	8.4	1	277.2
15. Common feature 03	2	54.0	2	54.0
Objective function value $F(x)$		1,694.6		1,708.0

Example from [RP]

WAS: weighted average satisfaction of stakeholder priorities

Table 2

Two qualified release plan alternatives, listing the release to which each feature is assigned and each weighted average satisfaction

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Feature $f(i)$	$x1(i)$	WAS(i,k)	$x2(i)$	WAS(i,k)
1. Cost reduction of transceiver	1	84.0	1	84.0
2. Expand memory on BTS controller	1	287.0	1	287.0
3. FCC out-of-band emissions	1	252.0	3	0.0
4. Software quality initiative	3	0.0	1	233.8
5. USEast, feature 1	1	134.4	3	0.0
6. USEast, feature 2	2	516.6	3	0.0
7. China feature 1	2	277.2	1	88.2
8. China feature 2	2	43.2	1	19.6
9. 12-carrier BTS for China	3	0.0	2	72.0
10. Pole-mount packaging	3	0.0	3	0.0
11. Next-generation BTS	3	0.0	3	0.0
12. India BTS variant	3	0.0	2	75.6
13. Common feature 01	1	37.8	1	516.6
14. Common feature 02	1	8.4	1	277.2
15. Common feature 03	2	54.0	2	54.0
Objective function value $F(x)$		1,694.6		1,708.0

TODO!

- Exercise 3 on functional requirements (Lauesen chapter 2-5)
- Hand in **Release R1** on Monday 09:00 & book meeting with supervisor
- Lab2 is not until next week but...
  - Two parts: **Quality requirements** and **Release planning**
  - Please note: Preparations for lab2 includes a lot of reading + working and take **significantly** more time compared to lab1, and is based on you attending both lectures and exercises (which help you with parts of your preparations)
  - Read [QUPER, RP]
- Next week's lecture on quality requriements is "flipped":
  - You watch the QUPER-video **before** the lecture
  - You come to the lecture on QR
  - You do Exercise 4 where you work on QR in your project
  - You do Lab 2 (bring preparations)