9th International Advanced School of
Empirical Software Engineering
September 21, 2011 - Banff, Alberta, Canada

Software release and version Planning – A decision-centric approach

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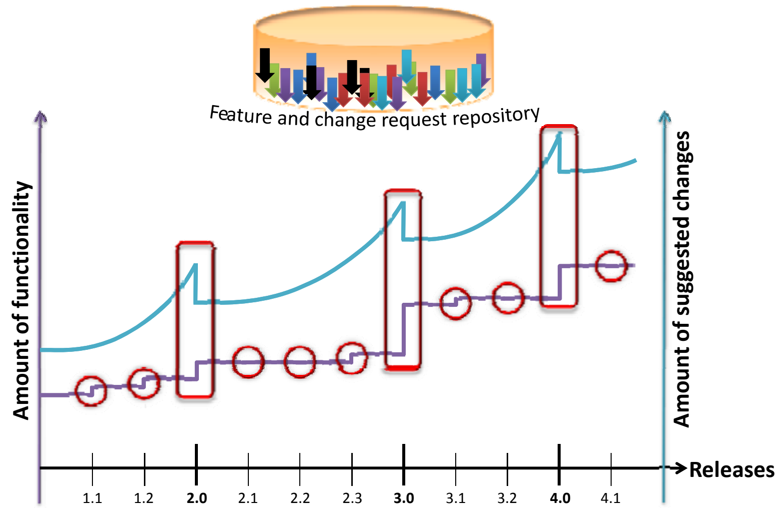
Agenda

1. Decisions in release and version planning
2. The process of decision-making
3. Strategic release planning: Randomized versus deterministic
4. Operational release planning: Deterministic AND randomized
5. When-to-release decisions
6. Summary and outlook

Release and version planning – What it is?



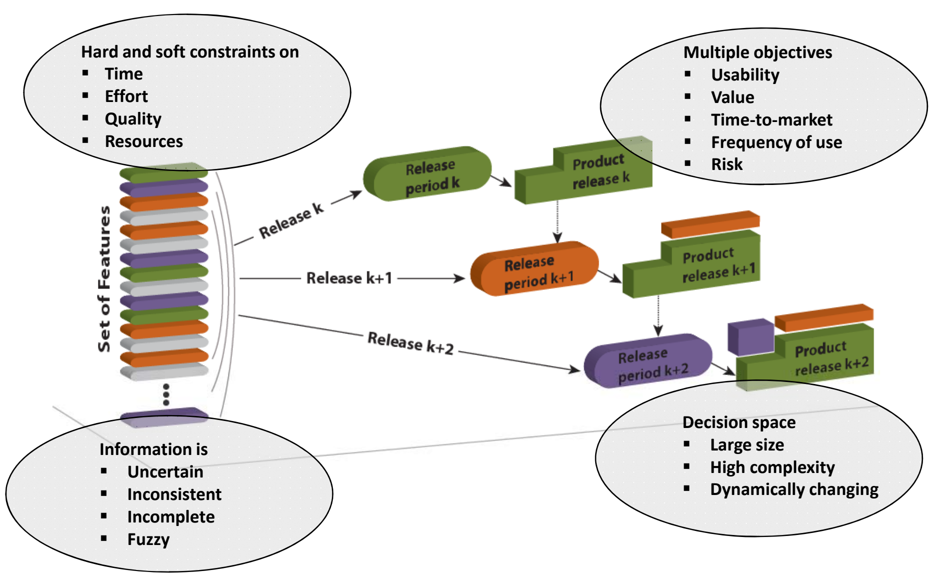
Release and versioning decisions

- Which features should be offered in the next release(s)?
- When is the best time for a product release?
- How to adjust to change for a given release?
  - When to re-plan?
  - How much to re-plan?
  - Which formerly planned features should be replaced by new ones?
  - How often re-planning can be done?
- When to create a customized version of a product release?

Key components of a decision

- Decision (independent) variables
  - determine which decision is to be made
  - are used to formulate constraints that have to be (or that should be) fulfilled by the decisions
  - are used to formulate objective(s) of decision-making.
- Result (outcome) variables
  - defines the results of decision-making
  - quantitative or non-quantitative relationship to decision variables.
- Uncontrolled variables
  - environmental factors that influence the decisions and their results, but are not/hard to control.

Release planning and versioning - Why difficult?



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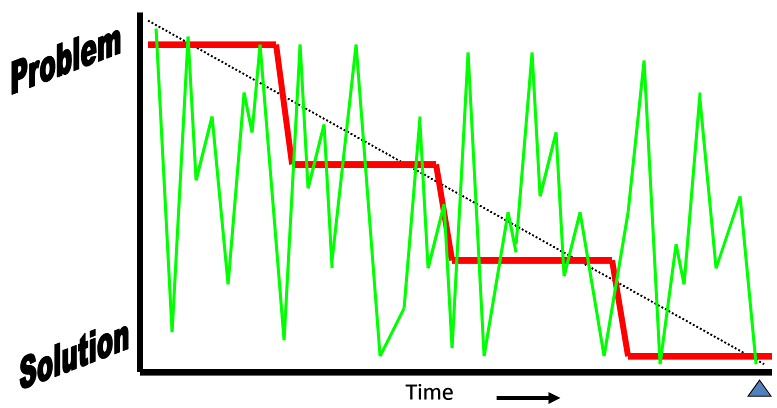
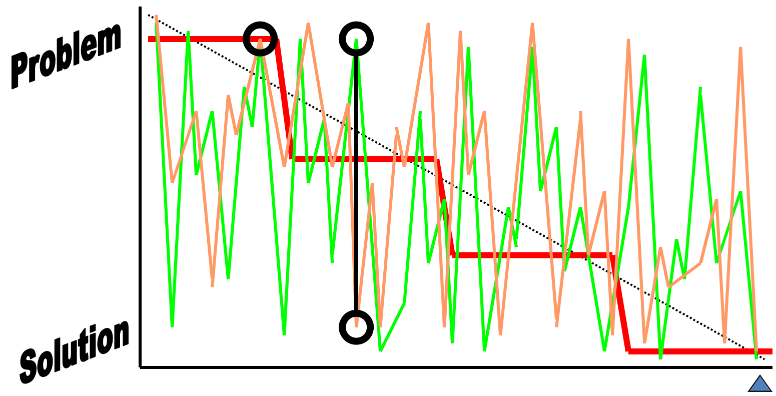
An experiment about human problem solving (1/2)



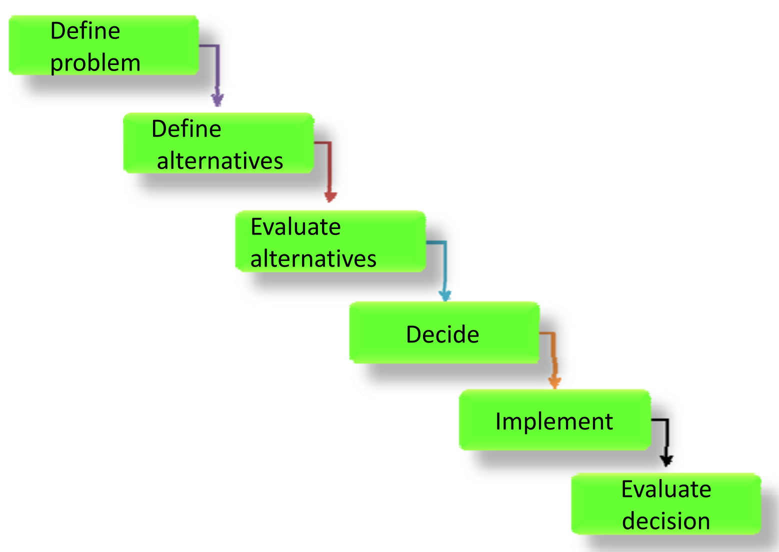
[1)] Jeff Conklin CogNexus Institute

An Experiment about humans problem solving (2/2)

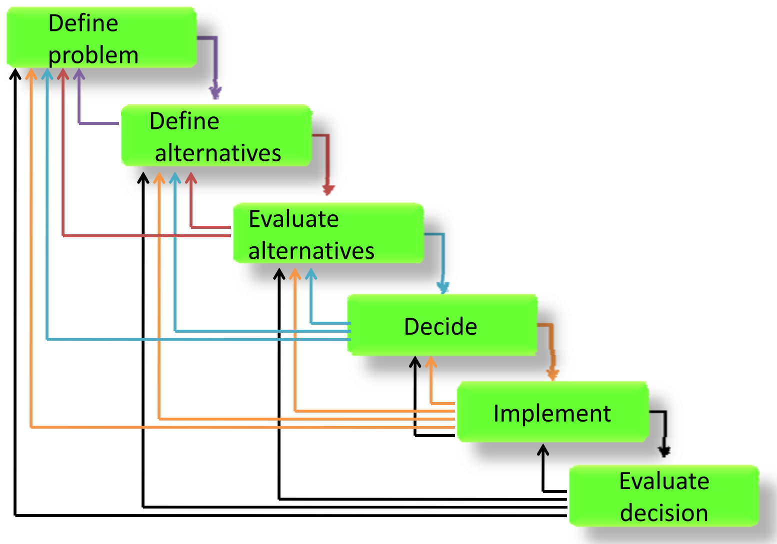


[1] Jeff Conklin CogNexus Institute

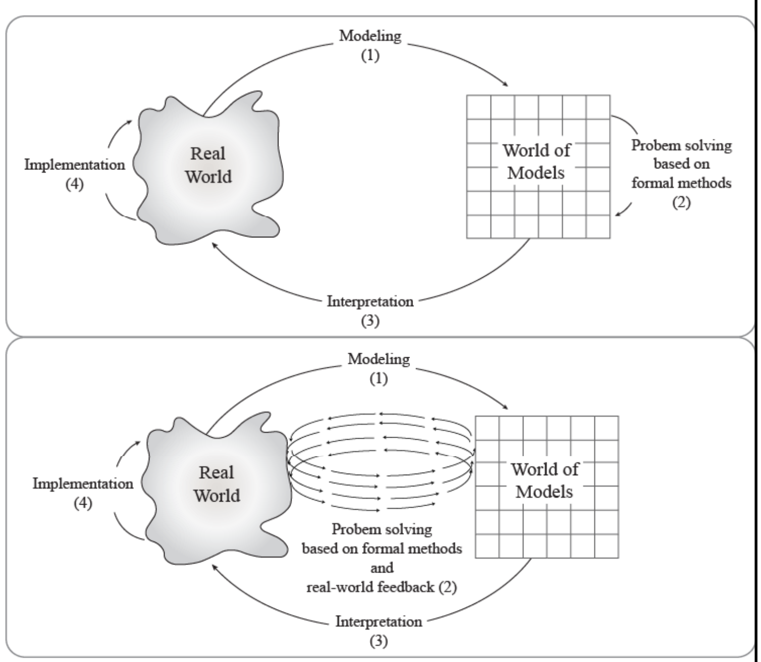
Decision process – Ideal view



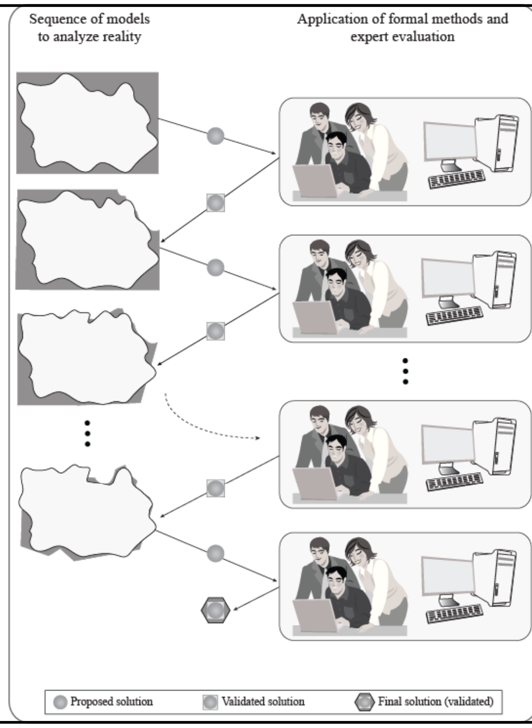
Decision process – Realistic view



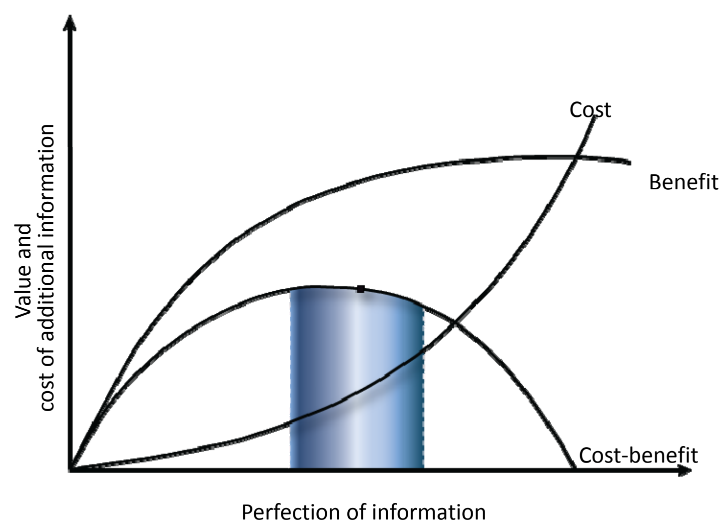
The principal approach of problem solving without (top) resp. with feedback (bottom)



Evolutionary problem solving process



Cost-benefit analysis of investment into decision support



ROI the better the more often investments are used

(Harrison 1987)

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Optimized release planning – How it began

EVOLVE: Greer, D. and Ruhe, G., Software Release Planning: An Evolutionary and Iterative Approach, Information and Software Technology, Vol. 46 (2004), pp. 243-253.

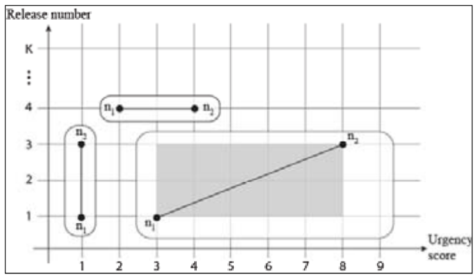
What constitutes a release plan?

$$\text{Max}\{ F(x, \alpha) = (\alpha - 1) F1(x) + \alpha F2(x) \text{ subject to } 0 \le \alpha \le 1, x \text{ from } X\}$$

- Stakeholders
- Weightings for stakeholders
- Scores of stakeholders towards urgency (F1) and value (F2)
- X composed of
  - effort constraints
  - coupling and precedence constraints (between features)

Optimized release planning – How it began

F1(x) is a penalty function defined for plan x describing the degree of violation of the monotonicity property between all pairs of features

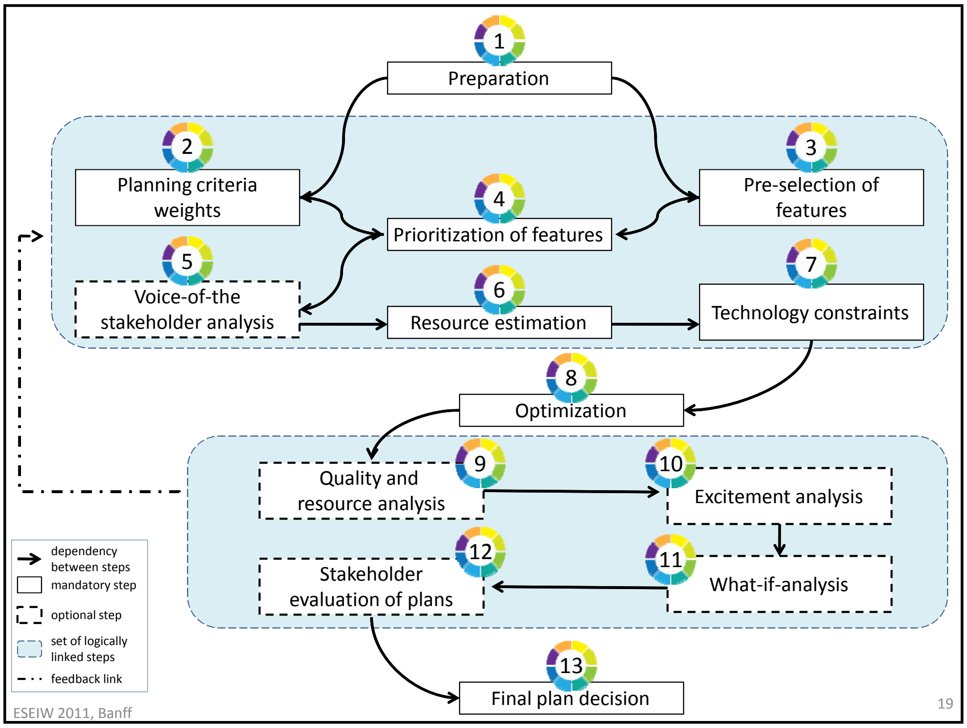


F2(x) is a benefit function based on feature scores of the stakeholders and the actual assignment of the feature according to the plan under consideration.

value(n,p) = value_score(n,p)(K – x(n) +1)

Empirical analysis

- EVOLVE was initially based on genetic search offered by Palisade's RiskOptimizer
- Early industrial feedback (Corel, Siemens)
- Development of our own GA (emphasis on avoiding premature convergence)
- Empirical studies with 200 to 700 requirements comparing the GA with running ILOG's CPLEX
- Better solutions for LP solver in reasonable time
- Known level of optimality
- Development of our own solution method utilizing open source optimization combined with knapsack-type of heuristic for B&B
- New approach based upon a more flexible model and with higher level of diversification among top solutions.



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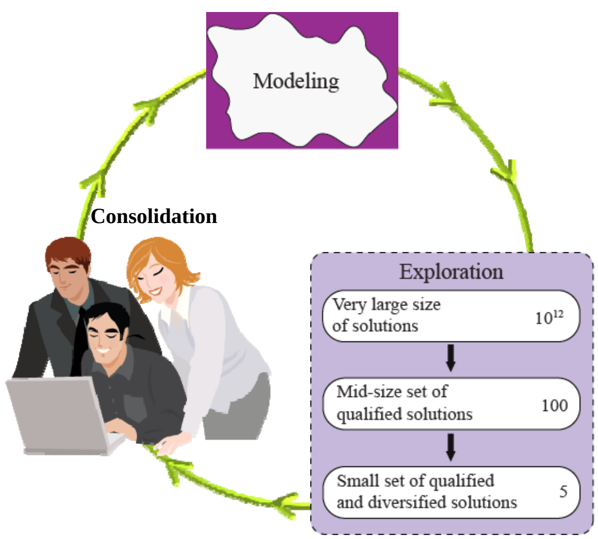
The diversification principle

A single solution

to a cognitive complex problem is less likely to reflect the actual problem when compared to a

portfolio of qualified solutions being structurally diversified



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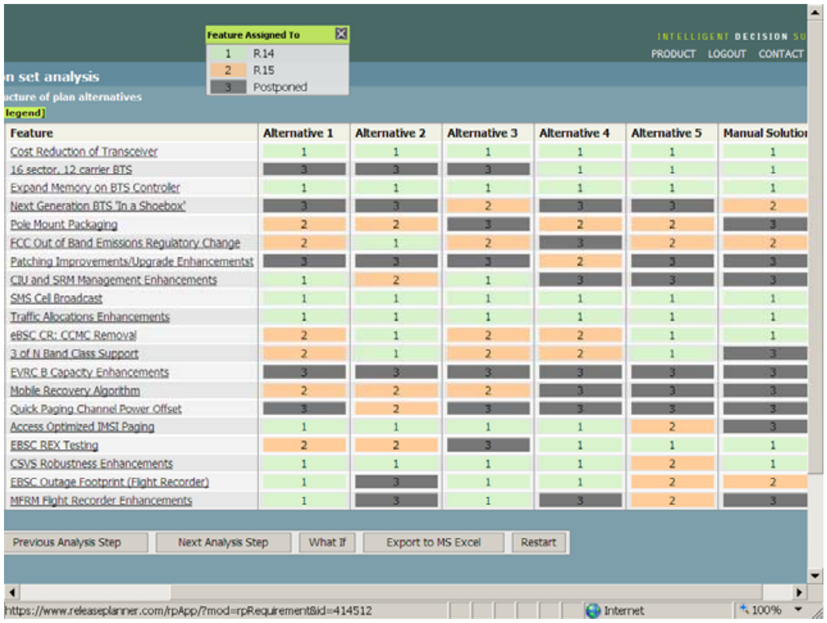
Diversified release plans



Feature	Alternative 1	Alternative 2	Alternative 3	Alternative 4	Alternative 5	Manual Solutior
Cost Reduction of Transceiver	1	1	1	1	1	1
16 sector, 12 carrier BTS	3	3	3	1	1	1
Expand Memory on BTS Controller	1	1	1	1	1	1
Next Generation BTS 'In a Shoebox'	3	3	2	3	3	2
Pole Mount Packaging	2	2	3	2	2	3
FCC Out of Band Emissions Regulatory Change	2	1	2	3	2	2
Patching Improvements/Upgrade Enhancementst	3	3	3	2	3	3
CIU and SRM Management Enhancements	1	2	1	3	3	3
SMS Cell Broadcast	1	1	1	1	1	1
Traffic Allocations Enhancements	1	1	1	1	1	1
eBSC CR: CCMC Removal	2	1	2	2	1	1
3 of N Band Class Support	2	1	2	2	1	3
EVRC B Capacity Enhancements	3	3	3	3	3	3
Mobile Recovery Algorithm	2	2	2	3	3	3
Quick Paging Channel Power Offset	3	2	3	3	3	3
Access Optimized IMSI Paging	1	1	1	1	2	3
EBSC REX Testing	2	2	3	1	1	1
CSVS Robustness Enhancements	1	1	1	1	2	1
EBSC Outage Footprint (Flight Recorder)	1	3	1	1	2	2
MFRM Flight Recorder Enhancements	1	3	1	3	2	3

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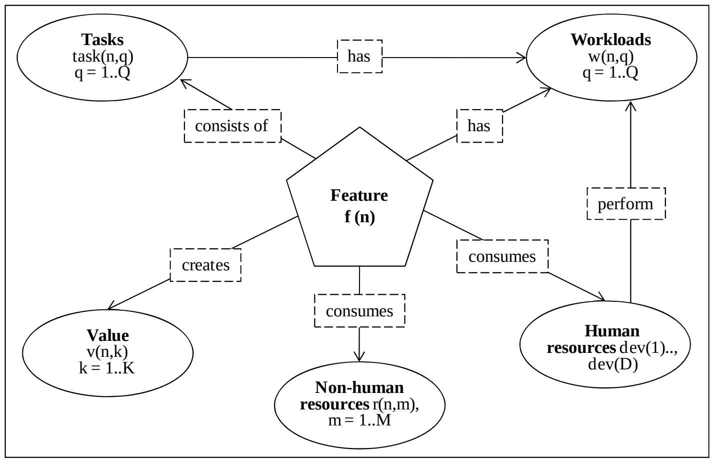
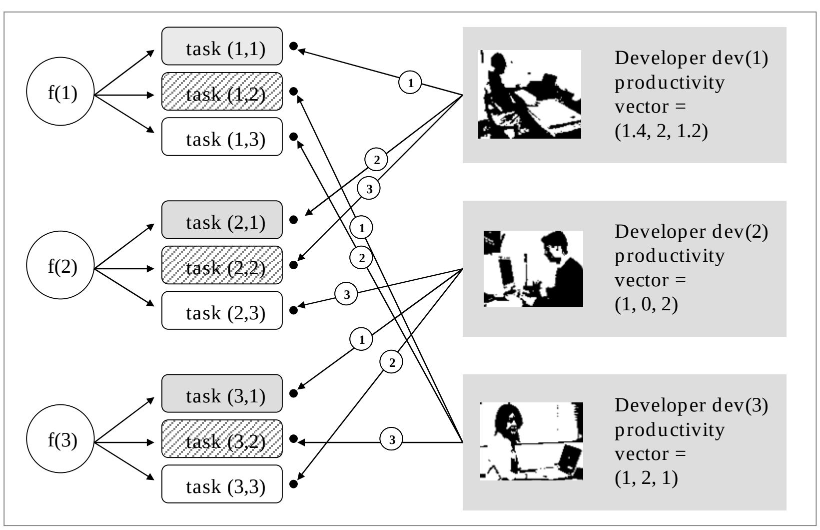
Operational planning: Data related to a feature f(n)

RASORP: A. Ngo-The, G. Ruhe, Optimized Resource Allocation for Software Release Planning, IEEE TSE, Volume 35 (2009), pp 109-123.

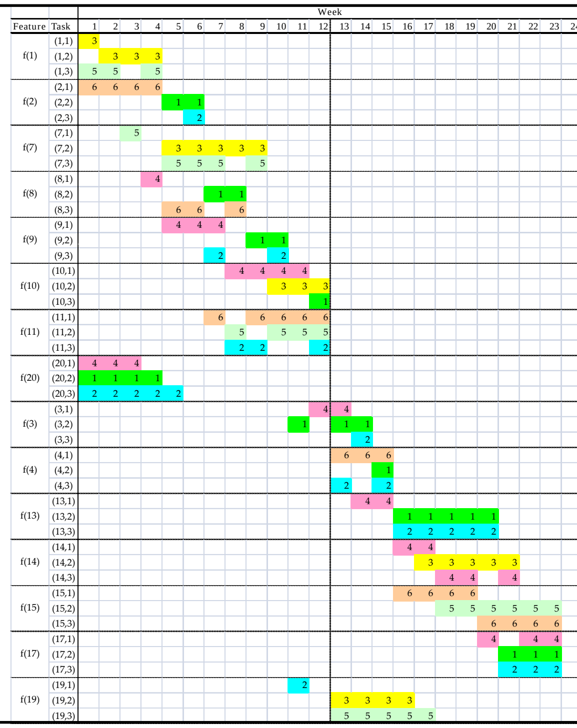
P. Kapur, A. Ngo-The, G. Ruhe, A. Smith, Optimized staffing for product releases and its application at Chartwell Technology, JSME Vol.20 (2008), pp 365-386



Assignment of developers to tasks of features



Sample Gantt Chart of operational planning



"The mere formulation of a problem is far more essential than its solution, which may be merely a matter of mathematical or experimental skills. To raise new questions (and), new possibilities, to regard old problems from a new angle, requires creative imagination and marks real advances in science."

(Albert Einstein, 1879-1955)

RASORP modeling (1/3)

- N - number of features under consideration,
- K - number of releases considered for planning,
- Q - number of tasks to be performed for each feature,
- D - number of developers available for assignment to tasks,
- t(k) - due date of release k (k = 1..K), and
- v(n,k) - value obtained by assigning feature n to release k (n = 1..N, k = 1..K)
- x(n,k) - delivery of features f(n) at release k
- u(d,t,n,q) – assignment of developer d at time t to task q of feature f(n)

RASORP modeling (2/3)

- Maximize { $F(x) = \Sigma_{n=1..N\ k=1..K}\ v(n,k)\cdot x(n,k)$ subject to $(u,x) \in UX$} where UX is the set of all feasible combination of staffing and release plans (u,x).
- $\Sigma_{k=1..K}\ x(n,k) \leq 1$ for n = 1..N
- $x(n_1,k) = x(n_2,k)$ for all coupled features $C(n_1,n_2)$ for k = 1..K
- $\Sigma_{k=1..K}\ (K+1-k)(x(n_1,k) - x(n_2,k)) \geq 0$, for all pairs of features being in precedence relationship $P(n_1,n_2)$
- $\Sigma_{t=t1..t2}\ \Sigma_{n=1..N}\ \Sigma_{q=1..Q}\ u(d,t,n,q) = 0$ for d = 1..D, l = 1..L(d), and twind(d,l) = [t1,t2]
- $\Sigma_{n=1..N}\ \Sigma_{q=1..Q}\ u(d,t,n,q) \leq 1$ for d = 1..D and t = 1..t(K)

RASORP modeling (3/3)

- $\Sigma_{t=1..t(K)}$ u(d,t,n,q) ≤ t(K)*z(d,n,q) for d= 1..D, n = 1..N and q = 1..Q
- $\Sigma_{d=1..D}$ z(d,n,q) ≤ 1 for n = 1..N and q = 1..Q
- $\Sigma_{d=1..D}$ $\Sigma_{t=1..t(k)}$ u(d,t,n,q)*prod(d,q) ≥ w(n,q)*$\Sigma_{k1=1..k}$ x(n,k_1) for k = 1..K, n = 1..N and q = 1..Q
- $\Sigma_{d=1..D}$ $\Sigma_{t1=1..t}$ u(d,t1,n,q) ≥ $\Sigma_{d=1..D}$ $\Sigma_{t1=1..t}$ u(d,t1,n,q+e) for t = 1..t(K), n = 1..N, q = 1..Q-1,
  w(n,q), w(n,q+e) > 0 and
  w(n,q*) = 0 for all q* = q+1..q+e-1
- $\Sigma_{d=1..D}$ $\Sigma_{t1=t..t(K)}$ u(d,t1,n,q+e) ≥ $\Sigma_{d=1..D}$ $\Sigma_{t1=t..t(K)}$ u(d,t1,n,q) for t = 1..t(K), n = 1..N, q = 1..Q-1, e = 1..Q – q,
  w(n,q), w(n,q+e) > 0 and
  w(n,q*) = 0 for all q* = q+1..q+e-1

RASORP algorithm - Phase 1 (packaging)

- Step 1.1
  Consider a simplified problem formulation RASORP* by ignoring the precedence constraints between the tasks implementing the features (just looking at t = t(k)'s).
- Step 1.2
  Apply branch and bound techniques in combination with linear programming (solving the relaxed problem without integrality constraints) to generate upper bounds and using a greedy heuristic to solve the sub-problem at each node of the branching tree.
- Step 1.3
  Obtain an optimized solution x1 which is taken as an input for Phase 2 to define a reduced search space.

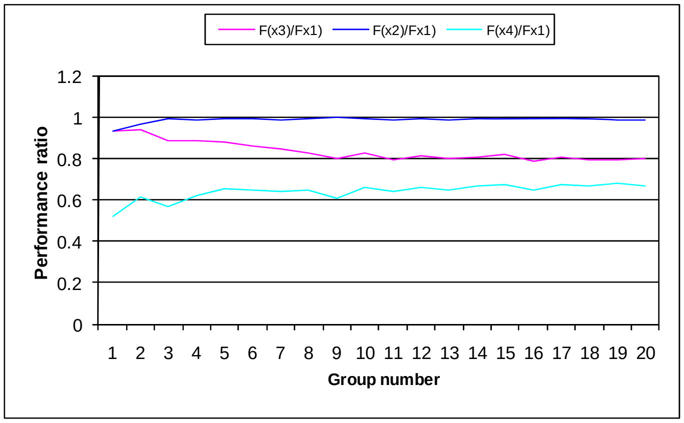
RASORP algorithm Phase 2 (scheduling)

- Step 2.1: Consider the complete problem RASORP.
- Step 2.2: Apply genetic algorithms to a reduced search space of permutations called ∏* (focused search) defined by the solution x1 from Phase 1.
  - Population size = 100,
  - Maximal number of generations = 500,
  - Probability of mutation = 1%,
  - Termination: If there is no improvement after 100 consecutive generations or the maximum number of generations is reached,
  - Percentage of new random solutions in each new generation= 10%,
  - Number of generations indicating that the population is stuck at a local optimum = 50, and
  - Proportion of new individuals when the population is stuck at a local optimum = 80%.
- Step 2.3: The resulting solution x2 has a degree of optimality of at least F(x2)/ F(x1).

Empirical analysis: Definition of groups

Group	Range N	Average K	Average M	Average Q	Average D	Average lPl	Average HR	Average NHR
1	5-14	2.667	1.852	3.333	2.111	0.111	0.689	0.681
2	15-24	2.296	1.704	3.333	2.333	0.481	0.689	0.696
3	25-34	3.037	1.778	3.333	3.111	0.667	0.693	0.707
4	35-44	2.148	1.926	3.333	3.370	1.852	0.715	0.685
5	45-54	2.259	1.741	3.333	3.741	1.889	0.726	0.704
6	55-64	2.630	1.778	3.333	4.741	3.000	0.711	0.726
7	65-74	2.333	1.889	3.333	5.407	2.889	0.689	0.722
8	75-84	2.444	1.741	3.333	5.333	3.704	0.711	0.715
9	85-94	2.815	1.926	3.370	7.074	3.444	0.674	0.704
10	95-104	2.370	1.704	3.333	7.037	5.074	0.693	0.730
11	105-114	2.667	1.926	3.667	8.111	6.185	0.711	0.719
12	115-124	2.370	1.704	3.667	8.926	6.741	0.711	0.719
13	125-134	2.111	1.889	3.667	10.556	7.111	0.685	0.700
14	135-144	2.111	1.926	3.667	10.815	7.259	0.674	0.715
15	145-154	2.148	2.037	3.630	13.519	6.037	0.726	0.719
16	155-164	2.481	1.963	3.630	13.593	7.852	0.707	0.674
17	165-174	2.148	2.000	3.630	15.000	9.444	0.700	0.704
18	175-184	2.074	1.852	3.630	13.963	10.593	0.681	0.693
19	185-194	1.963	1.778	3.519	14.111	9.667	0.696	0.719
20	195-204	1.963	1.926	3.630	17.074	8.963	0.719	0.719

Comparison between FS, UFS and greedy search



- x1 = optimized plan at the end of Phase 1
- x2 = plan received from application of focused search FS
- x3 = plan received from application of unfocused search UFS
- x4 = plan received from application of greedy search

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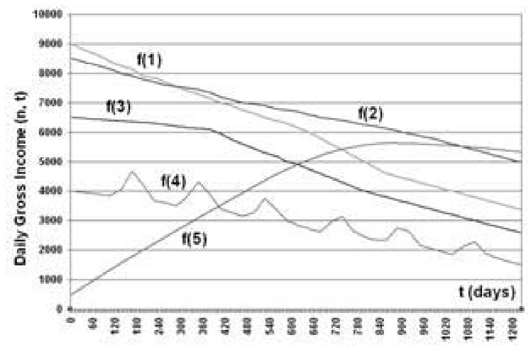
When-to-release decisions for features with time-dependent value functions

J. McElroy, G. Ruhe: When-to-release Decisions for Features with Time-dependent Value Functions, Requirements Engineering Journal, Requirements Engineering, Vol. 15 (2010), pp. 337-358

- Value functions are are continuous functions of time.



$$TNV(n,t) = \int_t^T DailyGrossIncome(n,t)\, dt$$

When-to-release decisions for features with time-dependent value functions

- Actual release dates are no longer fixed but can be varied in some pre-defined interval.

  Consumption(k,r,x) = $\sum_{n:x(n)=k}$ consumption(n,r) $\leq$ Capacity(k,r,t*(k)) for r = 1…R and k = 1…K

  t*(k) being from the interval [rd1(k), rd2(k)]
- Value(x, RD,T) = $\Sigma_{k=1\ldots K} \Sigma_{n: x(n)=k}$ TNV(n,rd(k))
- Risk(x, RD) = $\sum_{k=1..K} \alpha(k)\, [rd2(k) - rd(k)]^{\beta(k)}$
- Calculation of trade-off solutions balancing the risk of early release with the potential additional value.

  Trade-off {[Value(x, RD,T) , Risk(x, RD))] according to
  x $\in$ X(RD), RD = (rd(1)…rd(K)) with
  rd(k) $\in$ [rd1(k), rd2(k)] for all k = 1…K

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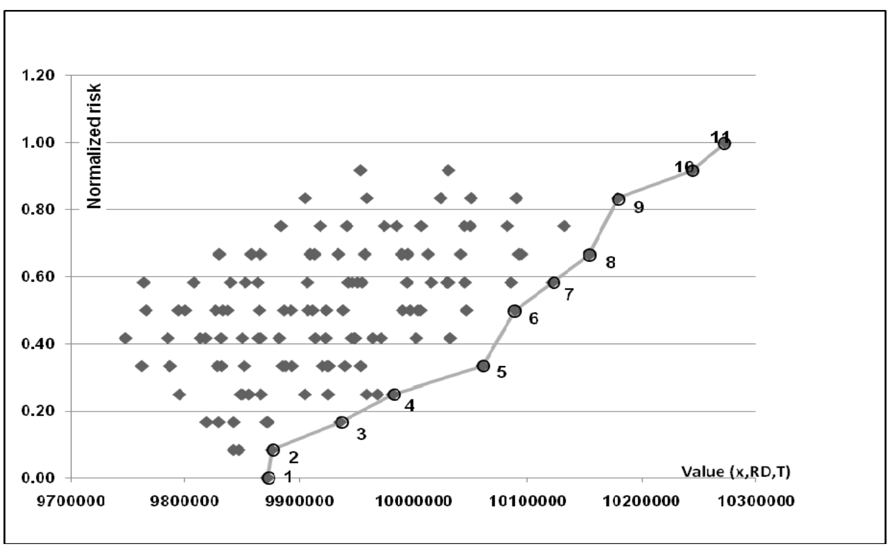
Risk-value trade-off solutions



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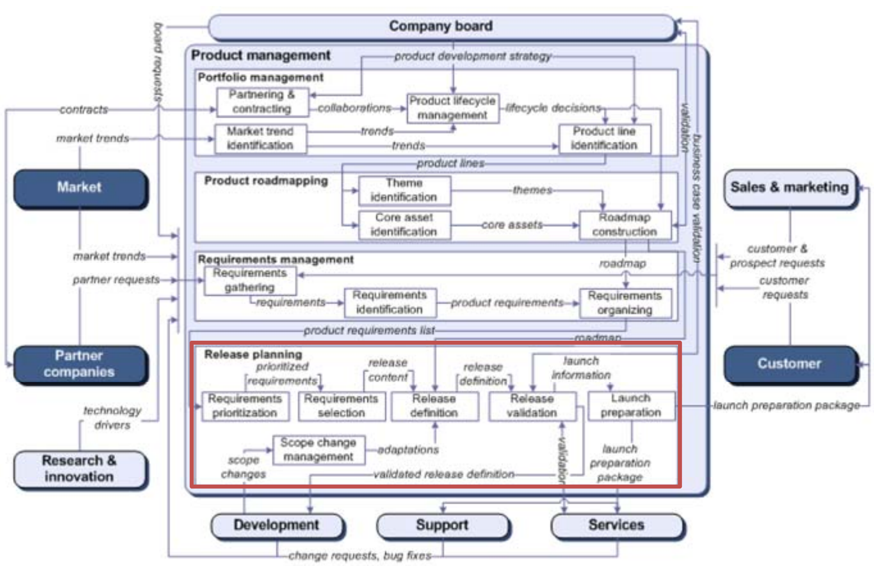
The bigger picture



Source: http://www.softwareproductmanagement.org/

Discussion

- It is more important to solve the right problem instead of solving a problem right
- Modeling is more influential than solving
- “Traditional” optimization has advantages, too
- Huge gap in transferring research results into industry
- (More) Empirical research needed into the nature of decision-making
- More evidence for usefulness is needed