CS5127/6027: Requirements Engineering

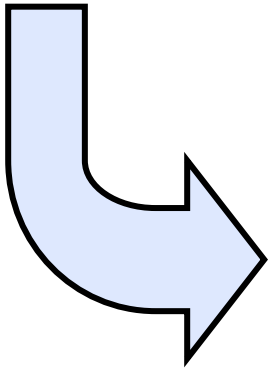
(Fall 2024)

Prof. Nan Niu (nan.niu@uc.edu)

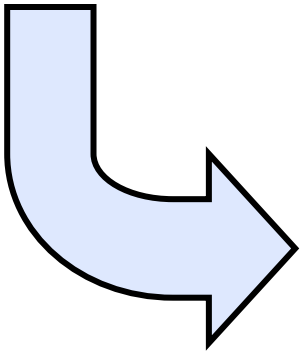
Office Hours: 10am-11am, Mondays, Rhodes 832

Today's Menu

Last Lecture (Monday 11/4):
Req.s Negotiation



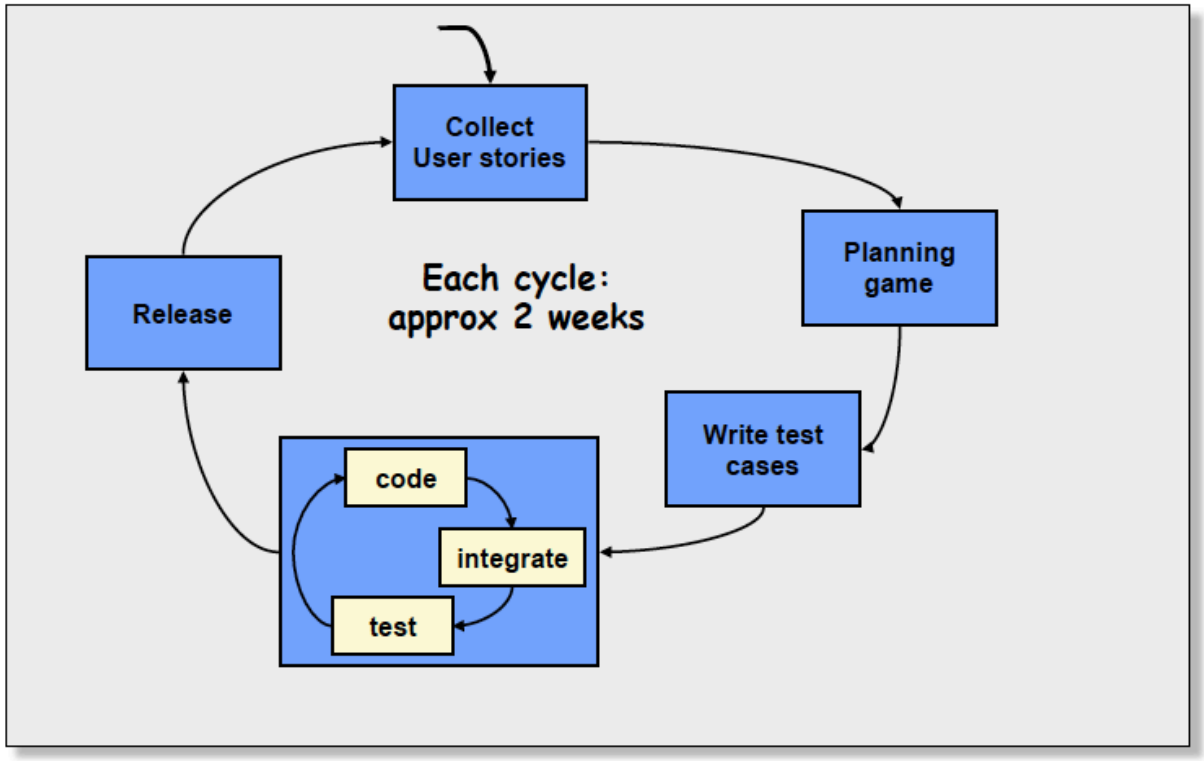
This Lecture (Friday 11/8):
Req.s Prioritization



Next Lecture (Friday 11/15):
OPTIONAL: ASN3 Q&As

When you have more than what you're able to do, you must prioritize.

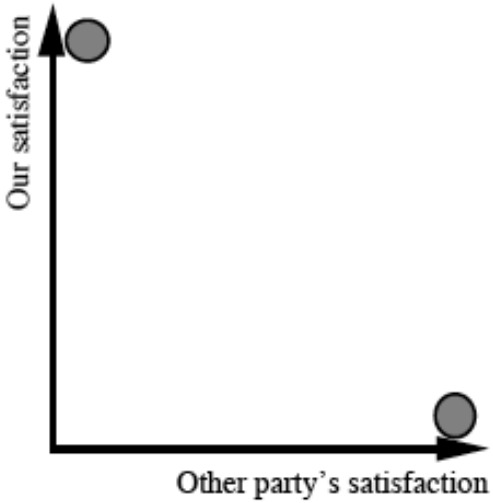
- Backlogs, including bells & whistles
- Market analysis, e.g., competitors
- …



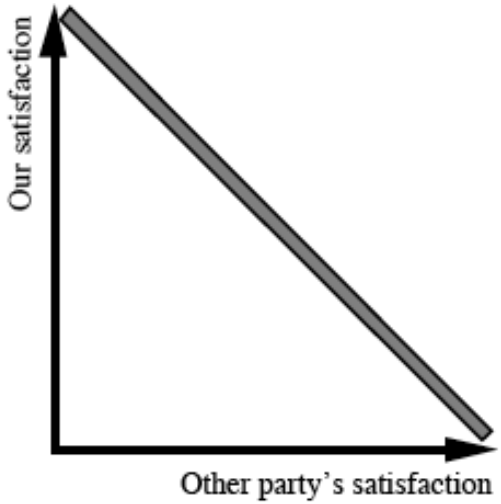
Prioritization Methods

- Negotiation
  - Face-to-face or distributed
  - Try to achieve a shared ranking
- Voting
  - Must-have, must-not, nice-to-have
  - Voting for the top one, or the top *k*
- Sorting/ranking
  - Total order: one-to-one comparison
- 100 Points
  - All participants distribute 100 points to all operations separately
  - Calculate the points for each operation & discuss the results jointly

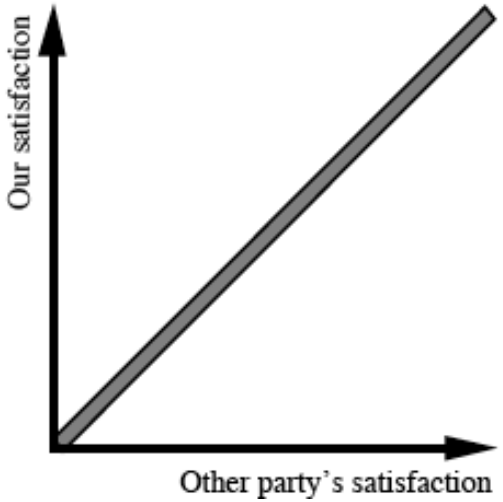
Joint Outcome Space



win/lose conflict



zero-sum conflict



reciprocal

Req.s are interrelated

→No matter if people do negotiation, sorting/ ranking, etc., some pay attention to

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

- P. Carlshamre, et al. *"An Industrial Survey of Requirements Interdependencies in Software Product Release Planning"*, RE'01, pp. 84-93, https://doi.org/10.1109/ISRE.2001.948547

Interdependencies: *how much?*

→ The industrial study's results show that:

- Only a few requirements are singular.
- Roughly, *20%* of the requirements are responsible for *75%* of the interdependencies.

→ Pareto principle

The **Pareto principle** (also known as the **80/20 rule**, the **law of the vital few** and the **principle of factor sparsity**[1][2]) states that for many outcomes, roughly 80% of consequences come from 20% of causes (the "vital few").[1]

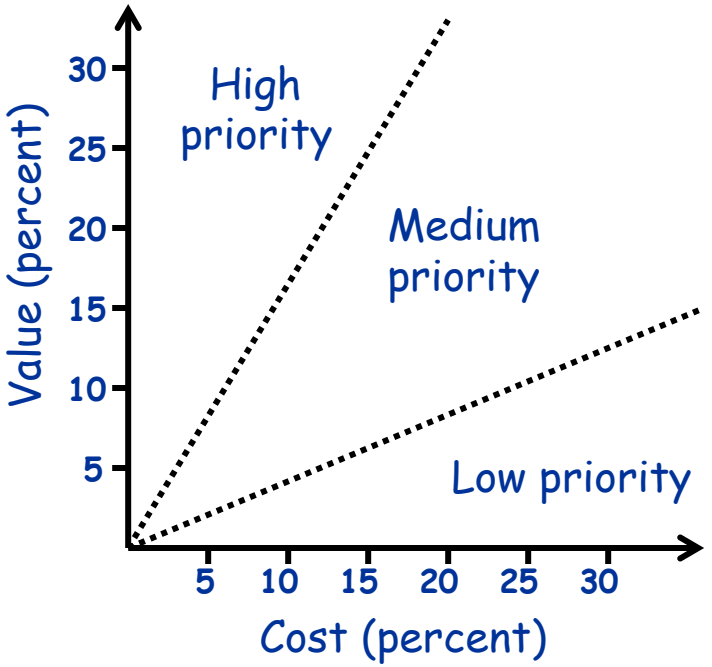
Questions arise:

- **How to find those 20% "vital few"?**
- **Can we afford to ignore the 20% unaccounted consequences?**
- **…**
- ***"Pareto front" coming up***

Sources: https://doi.org/10.1109/ISRE.2001.948547 *and* https://en.wikipedia.org/wiki/Pareto_principle

AHP as a Prioritization Method

- AHP: Analytic Hierarchy Process
- Usually there are too many requirements
  - Decide which to include in the first release
    - Balancing quality, cost and time-to-market
  - Assess each requirement's importance to the project as a whole
  - Assess the relative cost of each requirement
  - Compute the cost-value trade-off



Source: *Adapted from Karlsson & Ryan 1997*

AHP in Action

- Create n x n matrix (for n requirements)
- Compare each pair of requirements
  - For element (x,y) in the matrix enter:
    - 1 - if x and y are of equal value
    - 3 - if x is slightly more preferred than y
    - 5 - if x is strongly more preferred than y
    - 7 - if x is very strongly more preferred than y
    - 9 - if x is extremely more preferred than y
  - …and for (y,x) enter the reciprocal.
- Estimate the eigenvalues:
  - E.g. "averaging over normalized columns"
    - Calculate the sum of each column
    - Divide each element in the matrix by the sum of it's column
    - Calculate the sum of each row
    - Divide each row sum by the number of rows
- This gives a value for each requirement:
  - …based on estimated percentage of total value of the project

AHP Example

	Req1	Req2	Req3	Req4
Req1	1	1/3	2	4
Req2	3	1	5	3
Req3	1/2	1/5	1	1/3
Req4	1/4	1/3	3	1

Normalize columns

	Req1	Req2	Req3	Req4
Req1	0.21	0.18	0.18	0.48
Req2	0.63	0.54	0.45	0.36
Req3	0.11	0.11	0.09	0.04
Req4	0.05	0.18	0.27	0.12

Sum the rows

sum	sum/4
1.05	0.26
1.98	0.50
0.34	0.09
0.62	0.16

Source: *Adapted from Karlsson & Ryan 1997*

Let's practice AHP in class: *3 Zoom features*

→ r1: support for Apple Watch

- Zoom Meetings will be integrated with Apple Watch, allowing users to manage meetings directly from their wrist. Users will join, mute, end Zoom Meetings, and see upcoming meetings.

→ r2: expanded GIPHY search and display capabilities in Zoom Team Chat

- Users will view up to 30 GIF search results from GIPHY within the Zoom Team Chat app. The search results will load incrementally as the user types their query, providing a more dynamic and responsive experience.

→ r3: enhancements to trending GIFs display on mobile

- Users will access daily trending GIFs when opening the GIF panel in Team Chat. The GIG panel feature will feature an updated layout with a waterfall style grid that adapts to light and dark mode.

→ We, as a ***group***, will holistically fill out n*(n-1)/2=3 cells

Sources: *Zoom release notes and https://bpmsg.com/ahp/ahp-calc.php*

AHP Example

	Req1	Req2	Req3	Req4
Req1	1	1/3	2	4
Req2	3	1	5	3
Req3	1/2	1/5	1	1/3
Req4	1/4	1/3	3	1

Normalize columns

…Also: should compute the consistency index (because the pairwise comparisons may not be consistent)

	Req1	Req2	Req3	Req4
Req1	0.21	0.18	0.18	0.48
Req2	0.63	0.54	0.45	0.36
Req3	0.11	0.11	0.09	0.04
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AHP in Theory

- → More visible
  - Prioritization results in a graph, which also helps release planning
  - Either dimension is a ratio scale and Σ=1 (relative comparison)

- → More robust
  - Redundancy ➔ reliability
    - In this case, pairwise comparisons ➔ less sensitive to judgmental errors
    - Consistency ratio (CR): the smaller, the better

As a general rule, a CR of 0.10 or less is considered acceptable.

THE correct prioritization results

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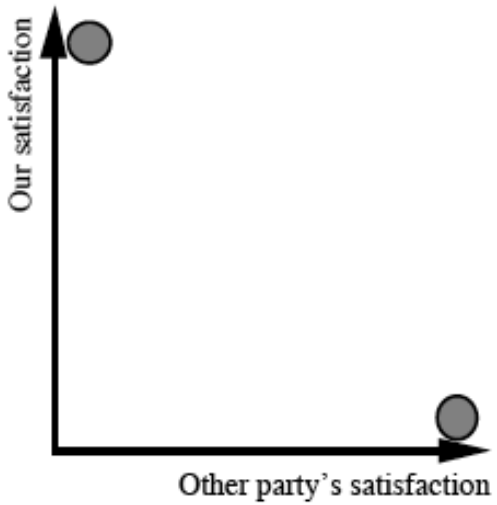
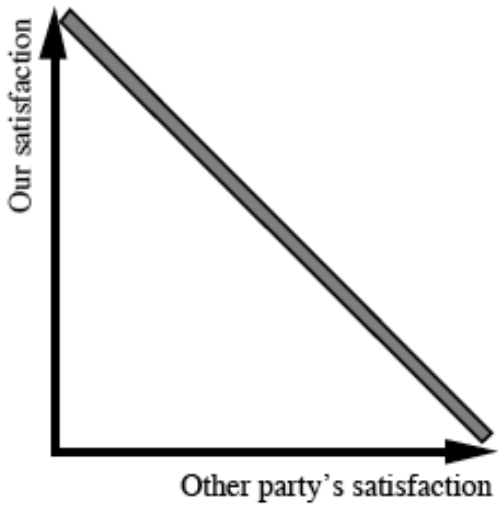
→ r2 (June 2024) > r1 (July 2024) > r3 (Aug 2024)

Sources: *Zoom release notes*

Joint Outcome Space



win/lose conflict



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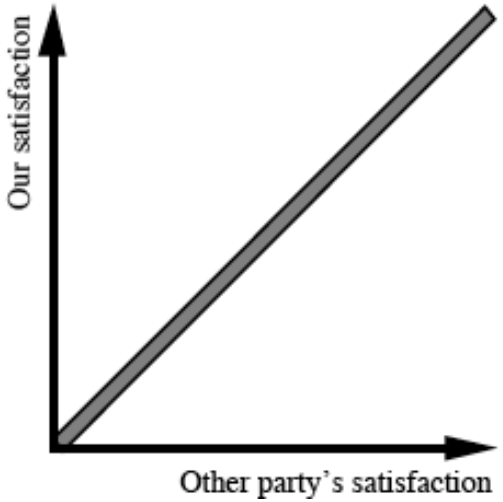

reciprocal

Search-Based Software Engineering

Req.	Value	Cost
r1: Create a new file	9	12
r2: Open an existing file	9	13
r3: Close current file	1	2
…	…	…
r50: searches a text in the document help file	6	2

The objective function is to:

maximizing value and minimizing cost.

Question: how many possible solutions are there?

Source: https://doi.org/10.1007/978-3-319-09940-8_9

Search-Based Software Engineering

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r3: Close current file	1	2
…	…	…
r50: searches a text in the document help file	6	2

2^{50} = 1,125,899,906,842,624

one quadrillion, one hundred and twenty-five trillion, eight hundred and ninety-nine billion, nine hundred and six million, eight hundred and forty-two thousand and six hundred and twenty-four

Source: https://doi.org/10.1007/978-3-319-09940-8_9

Pareto front

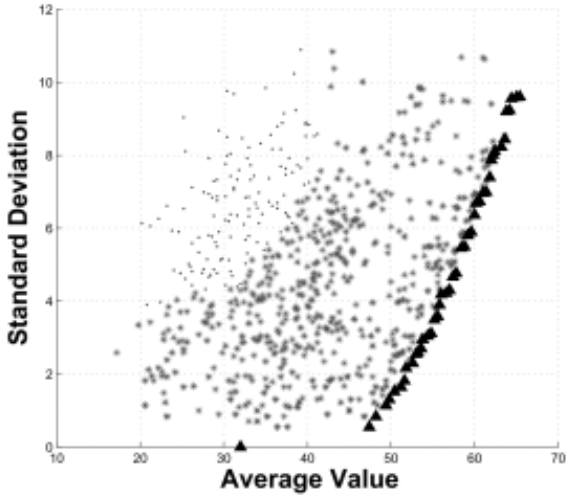
Req.	Value	Cost
r1: Create a new file	9	12
r2: Open an existing file	9	13
r3: Close current file	1	2
…	…	…
r50: searches a text in the document help file	6	2

sln	value	cost	remark
s1: [1, 0, 0]	9	12	
s2: [0, 1, 0]	9	13	s2 is dominated by s1
s3: [0, 0, 1]	1	2	s3 remains in the Pareto front
s4: [1, 0, 1]	10	14	s4 in the Pareto front or not?
s5: [0, 1, 1]	10	15	s5 in the Pareto front or not?
…	…	…	…

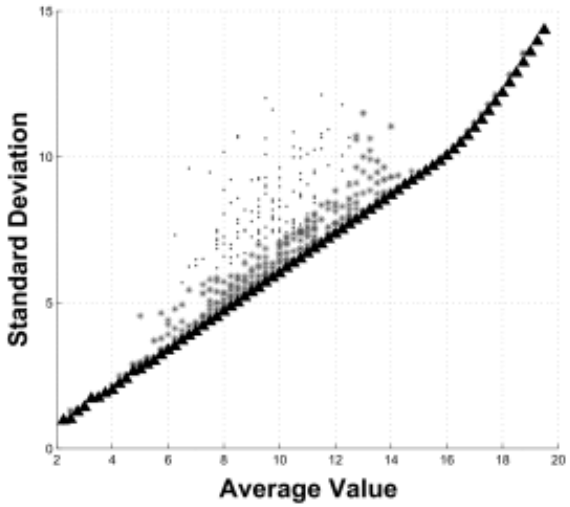
Source: https://en.wikipedia.org/wiki/Pareto_front

NSGA-II
(Non-dominated Sorting Genetic Algorithm-II)

- $O(mN^2)$, faster than NSGA, $O(mN^3)$
  - m: # of objectives
  - N: population size
- Active research on meta-heuristic and hyper-heuristic search



(a) Result for Random Data Set



(b) Result for Motorola Data Set

Source: https://doi-org.uc.idm.oclc.org/10.1109/RE.2008.61

Randy Pausch

Randy Pausch on Prioritization

	Due Soon	Not Due Soon
Important	1	2
Not Important	3	4

Source: *http://www.cs.virginia.edu/~robins/Randy/RandyPauschTimeManagement2007.pdf*

Randy Pausch on Time Management

You don't find time for important things, you make it

Everything you do is an opportunity cost

Source: *http://www.cs.virginia.edu/~robins/Randy/RandyPauschTimeManagement2007.pdf*

Today's Take-Aways

- Prioritization methods
  - Zero-sum: 100-point …
  - Interdependencies, AHP, …
  - Reciprocal: Search-based …

- To-do
  - Review today's slides
  - Graduate project video presentation is due: Friday, Nov 15
  - ASN3 is due: Wednesday, Nov 20
  - Next Friday (Nov 15): ***optional*** Q&As