CSIT113
Problem Solving

Week 12

Problem Classification

- Last week we examined the idea of problem complexity:
  - P—problems soluble in polynomial time
  - NP—problems with solutions verifiable in polynomial time.
  - P = NP?
- Despite being potentially complex, their solution is straightforward.
  - We have well-defined strategies
    - Brute force
    - Greedy
    - Divide and conquer
    - Backtrack
    - Branch and bound
    - Etc.

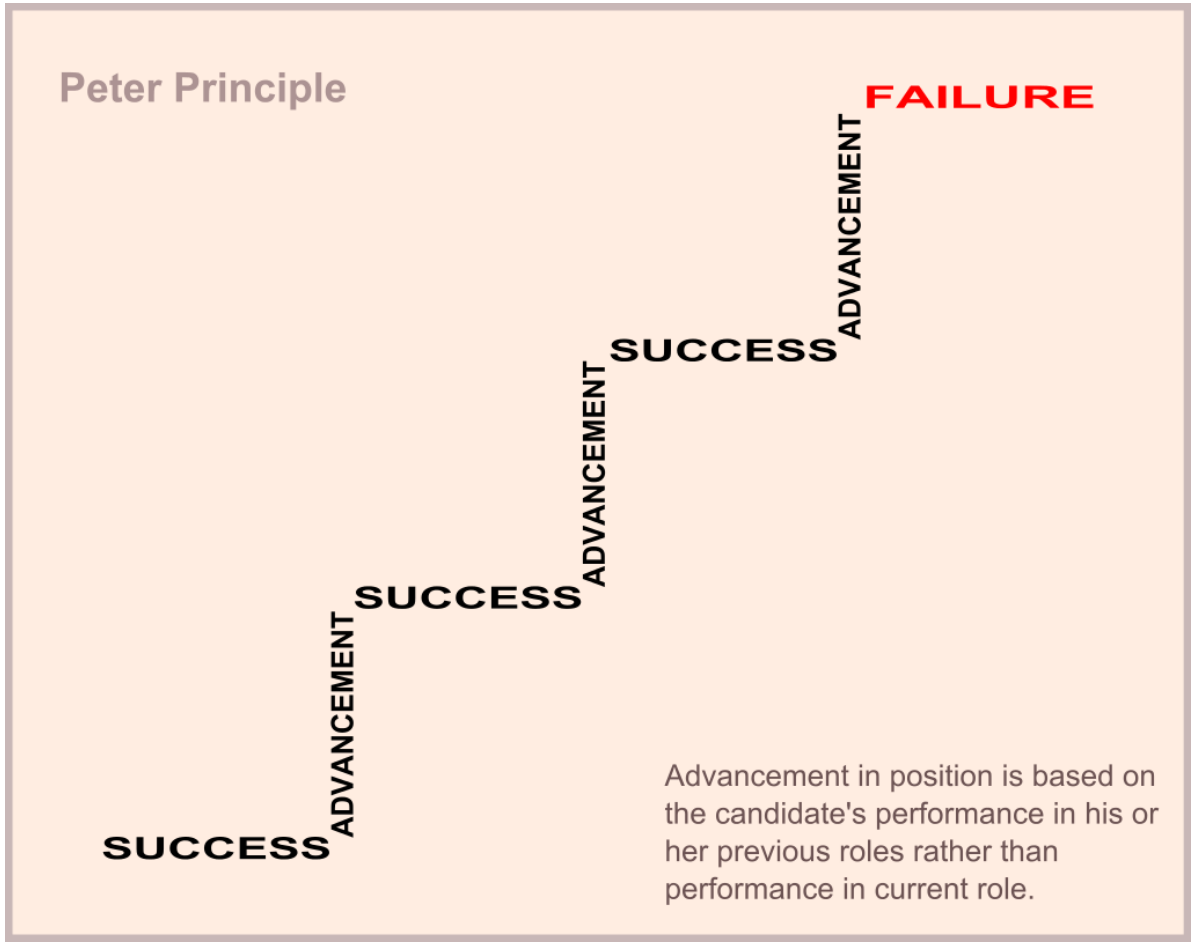
Wicked Problems

- Some problems are not just hard to solve—there is no clear way to even start to solve them.
- These are referred to as *wicked* problems.

> “Some problems are so complex that you
>
> have to be highly intelligent and well informed
>
> just to be undecided about them.”
>
> —Laurence J. Peter

Who?—An aside

- Laurence J. Peter:
  - Canadian Educator and Author (1919-1990)
  - Author of *The Peter Principle*
  - *“managers rise to the level of their incompetence”*



Wicked Problems: History

- A **wicked problem** is a **problem** that is difficult or impossible to solve because of incomplete, contradictory, and changing requirements that are often difficult to recognize.
- The use of term "**wicked**" here has come to denote resistance to resolution, rather than evil.
- The term was originally used by Horst Rittel in the context of social planning (1973).
- Later generalized by Jeff Conklin to a wider range of applications including engineering and Information Technology (2006).

Wicked Problems: Characteristics

- Rittel and Webber in 1973 described 10 characteristic features of wicked problems:
  1. There is no definitive formulation of a wicked problem.
  2. Wicked problems have no stopping rule.
  3. Solutions to wicked problems are not true-or-false, but good or bad.
  4. There is no immediate and no ultimate test of a solution to a wicked problem.
  5. Every solution to a wicked problem is a "one-shot operation"; because there is no opportunity to learn by trial and error, every attempt counts significantly.

Wicked Problems: Characteristics

- Rittel and Webber continued.
  6. Wicked problems do not have an enumerable (or an exhaustively describable) set of potential solutions, nor is there a well-described set of permissible operations that may be incorporated into the plan.
  7. Every wicked problem is essentially unique.
  8. Every wicked problem can be considered to be a symptom of another problem.
  9. The existence of a discrepancy representing a wicked problem can be explained in numerous ways. The choice of explanation determines the nature of the problem's resolution.
  10. The social planner has no right to be wrong (i.e., planners are liable for the consequences of the actions they generate).

Wicked Problems: Characteristics

- Conklin offered a set of six defining characteristics:
  1. You don’t understand the problem until you have developed a solution.
  2. Wicked problems have no stopping rule.
  3. Solutions to wicked problems are not right or wrong.
  4. Every wicked problem is essentially unique and novel.
  5. Every solution to a wicked problem is a ‘one shot operation.’
  6. Wicked problems have no given alternative solutions.
- Let us examine each of Conklin’s characteristics in turn.

1. You don’t understand the problem until you have developed a solution.

- Every solution that is offered exposes new aspects of the problem, requiring further adjustments of the potential solutions.
- There is no definitive statement of ‘The Problem.’
- The problem is ill structured, an evolving set of interlocking issues and constraints.
- Rittel: “One cannot understand the problem without knowing about its context; one cannot meaningfully search for information without the orientation of a solution concept; one cannot first understand, then solve.”
- What ‘the Problem’ is depends on who you ask – different stakeholders have different views about what the problem is and what constitutes an acceptable solution.

2. Wicked problems have no stopping rule.

- Since there is no definitive ‘The Problem’, there is also no definitive ‘The Solution.’
- The problem solving process ends when you run out of resources, such as time, money, or energy, not when some optimal or ‘final and correct’ solution emerges.
- Herb Simon, Nobel laureate in economics, called this ‘satisficing’ —stopping when you have a solution that is ‘good enough’.

3. Solutions to wicked problems are not right or wrong.

- They are simply ‘better,’ ‘worse,’ ‘good enough,’ or ‘not good enough.’
- With wicked problems, the determination of solution quality is not objective and cannot be derived from following a formula.
- Solutions are assessed in a social context in which “many parties are equally equipped, interested, and/or entitled to judge [them],” and these judgements are likely to vary widely and depend on the stakeholder’s independent values and goals.

4. Every wicked problem is essentially unique and novel.

- There are so many factors and conditions, all embedded in a dynamic social context, that no two wicked problems are alike, and the solutions to them will always be custom designed and fitted.
- Rittel: “The condition in a city constructing a subway may look similar to the conditions in San Francisco, say,… differences in commuter habits or residential patterns may far outweigh similarities in subway layout, downtown layout, and the rest.”
- Over time one acquires wisdom and experience about the approach to wicked problems, but one is always a beginner in the specifics of a new wicked problem.

5. Every solution to a wicked problem is a ‘one-shot operation.’

- Every attempt has consequences.
- Rittel: “One cannot build a freeway to see how it works.”
- This is the “Catch 22” about wicked problems:
  - you can’t learn about the problem without trying solutions,
  - but every solution you try is expensive
  - …has lasting unintended consequences
  - …which are likely to spawn new wicked problems.

6. Wicked problems have no given alternative solutions.

- There may be no solutions, or there may be a host of potential solutions that are devised, and another host that are never even thought of.
- It is a matter of creativity to devise potential solutions, and a matter of judgement to determine which are valid,

Some Examples:

- Do we route a new highway? Through the city or around it?
- How do we deal with crime and violence in the community?
- What do we do when the oil runs out?
- How do we address global warming?
- What features should we have in our new product?

A specific example:

- Let us consider a problem in more detail:
  - The design of a new car.
- We have formed a project team to consider the following problem:
  - The marketing department wants a design that emphasizes side-impact safety—they want to promote a new ‘safe car’.
- There is a deadline, a budget and a senior executive that the project reports to.
- Let us consider this problem in the light of Conklin’s six criteria:

1. You don’t understand the problem until you have developed a solution.

- One approach:
  - add structural support in the doors to make the car safer from side impact.
- It turns out that the additional door structure:
  - doubles the cost of the door,
  - makes the doors heavier and harder to open and close,
  - changes the fuel mileage and ride,
  - and requires an adjustment to the suspension and braking systems.

1. You don’t understand the problem until you have developed a solution.

- Making the doors stronger leads into other design problems, but also bounces back into marketing problems:
  - “What should the price be?”,
  - “How much do people really care about side impact survivability?”,
  - “What do customers really want in a car?”
- All of these problems interact with each other.
- At the senior executive level, the real question is:
  - “Should we continue this project to produce this new car?”

2. Wicked problems have no stopping rule.

- When does the car become ‘safe’?
- There is no natural stopping point in working out the tradeoffs among:
  - safety,
  - performance,
  - appearance,
  - and cost.
- At some point, the design team will be forced to make a decision.
- If it were not for project deadlines, the team would swirl indefinitely in ‘analysis paralysis’.

3. Solutions to wicked problems are not right or wrong.

- No amount of study, laboratory experiments, or market surveys will establish that that project team's solution is 'correct.'
- Ironically, when the car gets produced:
  - there will be reviews pointing out that the doors are heavy and difficult to open when parking on a hill,
  - there will still be law suits from people who were injured in side-impact accidents despite the stronger doors!

4. Every wicked problem is essentially unique and novel.

- Even if the project team has several successful car designs under its belt, the ‘safe door’ problem is essentially unique and novel, because of the configuration of issues and stakeholders.
- First, a recent study by a consumer safety organization suggests that side impact injuries would be reduced by side air bags, which are not a part of the design.
- Second, a side impact injury lawsuit has been filed against the company—if the new design is announced now, it may look like an acknowledgement of prior unsafe designs.
- Moreover, federal legislation is emerging that may put legal constraints on the strength of the doors. The design of safer doors is not merely a technical problem: it is a political and PR problem as well.

5. Every solution to a wicked problem is a ‘one-shot operation’.

- The creation of a safer car is a one-shot operation.
- When the new safer car finally reaches the market, it may be a flop, or it may change the safety standards for the whole industry.
- The design team can build prototypes of the car and test them, but there is no way to anticipate the unintended consequences of producing and selling the new vehicle.

6. Wicked problems have no given alternative solutions.

- The safe door problem does not have a few discrete possible solutions from which to choose.
- There is an immense space of options in terms of structural reinforcement, materials, cushioning, window design, hinge placement, and how the door latches and opens.
- The design team cannot select from a few options—it must collectively exercise creativity and judgement about an elegant resolution of all of the design priorities.

Tame Problems

- Not all problems that are hard are wicked.
- A ‘tame problem’ is one for which the standard approaches work.
- A tame problem:
  1. has a well-defined and stable problem statement,
  2. has a definite stopping point, i.e. when the solution is reached,
  3. has a solution which can be objectively evaluated as right or wrong,
  4. belongs to a class of similar problems which are all solved in the same similar way,
  5. has solutions which can be easily tried and abandoned,
  6. and comes with a limited set of alternative solutions.

Tame vs. Wicked

- A problem does not need all of the six characteristics to be classified as wicked,
- or as tame.
- In general, a problem is wicked as soon as it has any of the characteristics.
- Most wicked problems have significant tame components.
- What we are really saying is that many problems have some degree of wickedness.

A Semi-wicked Problem.

- Putting a man on the moon:
  - Tame aspects:
    - Main objective was wall defined and did not change.
    - It was obvious when the problem was clearly solved.
    - It was obvious if the solution succeeded (or failed).
  - Wicked aspects:
    - Designing the rocket.
    - Designing the capsule.
    - Designing the life support systems.
    - Funding.

Recognizing Wickedness

- You often can’t tell from the outside if a problem is going to be wicked
- Like the safe car design example, many problems appear tame on the surface, but are indeed wicked once you get into them.
- There is a natural inclination to see problems as tame, and to avoid the wicked ones.
- Who wants to take on a problem that, by definition, can’t be solved!?

Taming a Wicked Problem

- Often we can reduce the wickedness of a problem.
- The following are six ways to help ‘tame’ a wicked problem:
  1. Lock down the problem definition.
  2. Assert that the problem is solved.
  3. Specify objective parameters by which to measure the solution’s success.
  4. Cast the problem as ‘just like’ a previous problem that has been solved.
  5. Give up on trying to get a good solution to the problem.
  6. Declare that there are just a few possible solutions, and focus on selecting from among these options.
- Note: these often do more to deny the wickedness rather than really tame it.

1. Lock down the problem definition.

- Develop a description of a related problem or a sub-problem that you can solve, and declare that to be the problem.
- Resist all efforts to expand or modify the problem definition.
- For example, if the problem is how to reduce violence in schools, you could focus on the much more tractable problem of how to install metal detectors in all school entrances.
- As another example, in the software field, one learns to ‘freeze the requirements’ as a way to lock down the problem.

2. Assert that the problem is solved.

- Since a wicked problem has no definitive solution, the whole point of attempting to tame it is so that a solution can be reached.
- Usually this step requires locking the problem down (see point 1), though it is possible to simply assert that the problem is ‘solved’ without clarity about what the problem was.
- Such assertions, however, generally require considerable authority to appear successful, such as in an autocratic organization or a dictatorship.
- As an example illustrates, one way of dealing with a United Nations resolution demanding that you destroy all weapons of mass destruction in your country is to simply assert that you have done so.
- It should be clear that this approach to taming a problem depends critically on the evidence that you offer that the problem is solved.

3. Specify objective parameters by which to measure the solution's success.

- This is the measurement approach.
- For example, to find out if we have solved the problem of school violence, we might count the number of deaths and injuries on school property—if this measure drops to zero, then we have solved the problem.
- This taming approach amounts to locking the problem down (point 1), however, because what is measured becomes, officially and by definition, the problem. Whatever is not measured is then free to absorb the real problem.
- With intense enough focus, we might reduce the number of violent incidents on the school grounds to zero … problem solved! … but overlook new problems that had been created, such as a sharp rise in violent incidents just off of the school grounds.

4. Cast the problem as ‘just like’ a previous problem that has been solved.

- Ignore or filter out evidence that complicates the picture.
- Refer to the previous solution of the related problem:
  - “It’s just like that problem. Just do the same thing again.”
- For example, there is a saying in military circles that “we always fight the last war,” meaning the tendency to assume that the enemy will behave as he did in the last war.

5. Give up on trying to get a good solution to the problem.

- Just follow orders, do your job, and try not to get in trouble.
- Maybe the organization will fix the serious problems in the current solution in a revised version or release next year.

6. Declare that there are just a few possible solutions, and focus on selecting from among these options.

- A specific way to do this is to frame the problem in ‘either/or’ terms,
- e.g. “Should we do the lock down or let the virus spread and people get autoimmune?”

Ok—You Can’t Tame Wicked Problems.

- Attempting to tame a wicked problem, while appealing in the short run, fails in the long run.
- The wicked problem simply reasserts itself, perhaps in a different guise, as if nothing had been done.
- Or, sometimes, the tame ‘solution’ makes the problem even worse.

Wicked Problems in Information Technology.

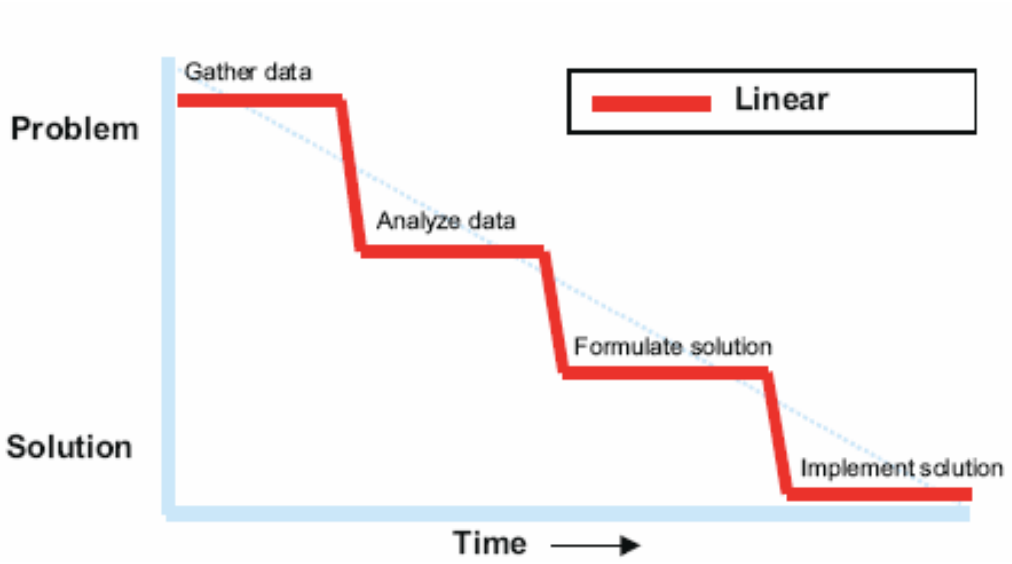
- Information Technology (and Computer Science) are no strangers to wicked problems.
  - Often, IT/CS is the problem (or, at least, a major contributor to it).
  - Sometimes, IT/CS helps solve the problem.
- Let us look at the problem of software design as an example of the first category.

Software Design as a Wicked Problem.

- Traditionally software engineers regard the problem of designing and implementing a piece of software as a relatively tame problem.
- There are well-defined approaches of varying complexity but most attempt to *linearize* the design process.
- Typical of this is the *Waterfall Model* of software design.
- The more complex the problem is, the more important it is to follow this orderly flow.

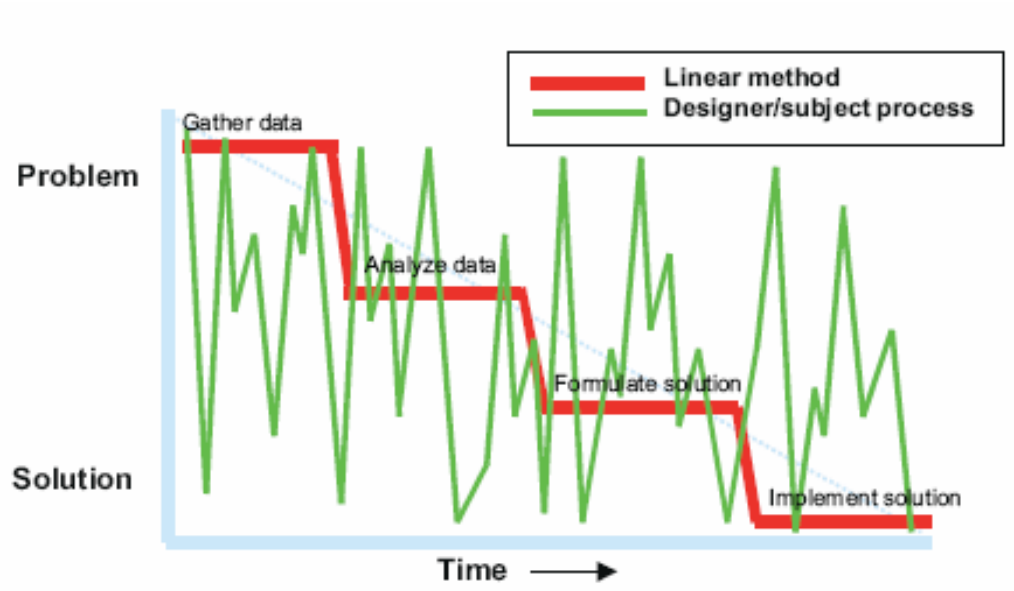
The Waterfall Model (in Theory)

- The waterfall represents the progression from problem to solution in a series of well-behaved steps.
- There is only one problem…
- That is not the way problems really get solved:



The Waterfall Model (in Practice)

- 1980's study of a complex design problem.
- Experienced designers/engineers given a problem to solve:
  - Design an elevator system for a large building.
- Researchers recorded the design process by getting participants to describe what they were doing/thinking as they went.



What this Means

- Problem solving is not a nice, linear process.
- We more fully understand and refine the problem while we solve it.
- This real-life approach to problem solving may look chaotic but it is, in fact, highly effective.

What this Means

- From another perspective, the jagged line of opportunity-driven problem solving is a picture of learning.
- The more novel the problem, the more the problem solving process involves learning about the problem domain.
- In this sense the waterfall is a picture of already knowing—you already know about the problem and its domain, you know about the right process and tools to solve it, and you know what a solution will look like.
- Most projects in the knowledge economy operate much more in the realm of learning than already knowing.

IT as Part of the Problem

- Many wicked problems have information technology embedded as part of the problem.
- Consider the issue of personal privacy vs. national security.
  - Government:
    - “A national security database with every one’s details will enhance security.”
    - “We need to maintain records of all emails to fight terrorism.”
    - “We need a way to break any encryption scheme to ensure it is not being used to harm national security.”
  - Libertarians:
    - “Big Brother is watching our every action.”
    - “You can’t have security at the price of privacy,”
    - “The potential for abuse is too great.”
- And these are just two of the stakeholders!

Technical Complexity

- A large negative contribution to wickedness comes from technical complexity:
  - What hardware do we use/support?
  - What operating system?
  - What language do we code in?
  - Which version?
  - Which libraries?
  - Which database?
  - Etc.
- Add to this a rapidly changing hardware/software environment.
  - Today’s solution may not even work tomorrow.
  - Tomorrow’s solution may not work today. (Or even tomorrow!)

Social Complexity

- The other factor that increases the difficulty of problems is social complexity.
  - The more parties involved in a problem, the more socially complex it is.
  - The more different those parties are, the more socially complex it is.
- Every stakeholder is likely to:
  - assume that everyone else knows what they mean,
  - assume that they know what everyone else means.
  - Both of these assumptions are almost certainly wrong!
- Remember the ‘safe car’ team?

The Team

- Bob, from Marketing,
  - has been conducting studies and focus groups that indicate a lot of interest in cars that are safer in a collision.
  - He is concerned with how to package a new ‘safe car’ in a way that is positive, sexy, and up-beat.
- Christine, from Engineering,
  - is very concerned about making the doors too heavy,
  - but she has worked on structural integrity in the past and is excited about new technologies that, while expensive, could make the doors both stronger and lighter.
- Harry, the representative from the Management Team,
  - sees the big issue as cost – top management is pushing affordability and value as the new strategy to increase sales.
- Alan, from IT,
  - has a mandate from his management to get this team to use the new CAD (Computer Aided Design) system on this project.
- Not to mention team members from:
  - Regulatory Affairs, Finance, Graphic Design, Power Train, and Quality Assurance.

The Team

- Every member of the team has:
  - their own experience,
  - personality type,
  - style of thinking
  - and style of learning.
- Each member adds their own jagged line to the graph.
- Each member:
  - comes from a different discipline,
  - has a different perspective,
  - has a different language
  - and possibly has a different goal.

Putting it Together

- “Because of social complexity, solving a wicked problem is fundamentally a social process. Having a few brilliant people or the latest project management technology is no longer sufficient.”

—Jeff Conklin

- “In times of stress the natural human tendency is to find fault with
  someone else.
  We tend to take the problem personally, at an organizational level, and assume that the chaos we see is a result of incompetence or, worse, insincere leadership.
  Since our education and experience have prepared us to see and solve tame problems, wicked problems sneak up on us and create chaos.
  Without understanding the cause, there is finger-pointing instead of learning.”

  —Jeff Conklin

IT to the Rescue?

- Apart from being (part of) the problem IT/CS may help toward ‘solving’ the problem.
- Software tools may:
  - support cooperation in teams,
  - promote better understanding by providing a common language,
  - help combat fragmentation (the blind men and the elephant),
  - support the development of a common mental model
  - as well as providing tools for communicating, sharing and recording information, ideas and decisions.
  - allow ‘solutions’ to be tested via modelling and/or simulation.

- A number of software-based (or assisted) techniques for helping with wicked problems.
- These include:
  - mess mapping,
  - resolution mapping,
  - dialogue mapping,
  - and agile project management approaches such as scrum.

Some Final Quotes.

- “There is always an easy solution to every human problem
  —neat, plausible and wrong.”
  —H. L. Mencken
- “Anything that can go wrong, will go wrong.”
  —Edward A. Murphy
- “Murphy was an optimist.”
  — Smith
- “Everything takes longer and costs more.”
  —Jerry Pournelle
- “Even when you take Pournelle’s law into account.”
  —Douglas Hoffstadter