Heuristics

A Collection

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v1.0 December 2013

Source: A significant part is from Mark W. Maier and Eberhardt Rechtin's *The Art of Systems Engineering 3rd Ed*

Multitask Heuristics

- D Performance, cost, and schedule cannot be specified independently. At least one of the three must depend on the others.
- D With few exceptions, schedule delays will be accepted grudgingly; cost overruns will not, and for good reason.
- D The time to completion is proportional to the ratio of the time spent to the time planned to date. The greater the ratio, the longer the time to go.
- D Relationships among the elements are what give systems their added value.
- D Efficiency is inversely proportional to universality. (Douglas R. King, 1992)

Multitask Heuristics /2

- D Murphy's Law, "If anything can go wrong, it will.
  - P Simplify. Simplify. Simplify.
  - P The first line of defense against complexity is simplicity of design.
  - P Simplify, combine, and eliminate. (Suzaki, 1987)
  - P Simplify with smarter elements. (N. P. Geiss, 1991)
  - P The most reliable part on an airplane is the one that isn't there — because it isn't needed. [DC-9 Chief Engineer, 1989]
- One person's architecture is another person's detail. One person's system is another's component. [Robert Spinrad, 1989]
  - P In order to understand anything, you must not try to understand everything. (Aristotle, 4th cent. B.C.)
- Don't confuse the functioning of the parts for the functioning of the system. (Jerry Olivieri, 1992)

Multitask Heuristics /3

- In general, each system level provides a context for the level(s) below. (G. G. Lendaris, 1986)
  - P Leave the specialties to the specialist. The level of detail required by the architect is only to the depth of an element or component critical to the system as a whole. (Robert Spinrad, 1990) But the architect must have access to that level and know, or be informed, about its criticality and status. (Rechtin, 1990)
  - P Complex systems will develop and evolve within an overall architecture much more rapidly if there are stable intermediate forms than if there are not. (Simon, 1969)
- Particularly for social systems, it's the perceptions, not the facts, that count.
- D In introducing technological and social change, how you do it is often more important than what you do.
  - P If social cooperation is required, the way in which a system is implemented and introduced must be an integral part of its architecture.

Multitask Heuristics /4

- If the politics don't fly, the hardware never will. (Brenda Forman, 1990)
  - D Politics, not technology, sets the limits of what technology is allowed to achieve.
  - D Cost rules.
  - D A strong, coherent constituency is essential.
  - D Technical problems become political problems.
  - D There is no such thing as a purely technical problem.
  - D The best engineering solutions are not necessarily the best political solutions.
- Good products are not enough. Implementations matter. (Morris and Ferguson, 1993)
  - P To remain competitive, determine and control the keys to the architecture from the very beginning.
  - The beginning is the most important part of the work. (Plato, 4th cent. B.C.)
  - Scope! Scope! Scope! (William C. Burkett, 1992)

Multitask Heuristics /5

- D Success is defined by the beholder, not by the architect.
  - D P The most important single element of success is to listen closely to what the customer perceives as his requirements and to have the will and ability to be responsive. (J. E. Steiner, 1978)
  - P Ask early about how you will evaluate the success of your efforts. (Hayes-Roth et al., 1983)
  - P For a system to meet its acceptance criteria to the satisfaction of all parties, it must be architected, designed, and built to do so — no more and no less.
  - P Define how an acceptance criterion is to be certified at the same time the criterion is established.
  - D Given a successful organization or system with valid criteria for success, there are some things it cannot do — or at least not do well. Don't force it!
  - P The strengths of an organization or system in one context can be its weaknesses in another. Know when and where.

Multitask Heuristics /6

- D Success is defined by the beholder, not by the architect /2.
  - D There's nothing like being the first success.
  - P If at first you don't succeed, but the architecture is sound, try, try again. Success sometimes is where you find it. Sometimes it finds you.
  - D A system is successful when the natural intersection of technology, politics, and economics is found. (A. D. Wheelon, 1986)
  - D Four questions, the Four Whos, need to be answered as a self-consistent set if a system is to succeed economically; namely, who benefits?, who supplies?, who pays? and, as appropriate, who loses?
- D Risk is (also) defined by the beholder, not the architect.
  - P If being absolute is impossible in estimating system risks, then be relative.

Multitask Heuristics /7

- D No complex system can be optimum to all parties concerned, nor all functions optimized.
  - P Look out for hidden agendas.
  - P It is sometimes more important to know who the customer is than to know what the customer wants. (Whankuk Je, 1993)
  - D The phrase, "I hate it," is direction. (Lori I. Gradous, 1993)
- P Sometimes, but not always, the best way to solve a difficult problem is to expand the problem, itself.
  - P Moving to a larger purpose widens the range of solutions. (Gerald Nadler, 1990)
  - P Sometimes it is necessary to expand the concept in order to simplify the problem. (Michael Forte, 1993)
  - P [If in difficulty,] reformulate the problem and re-allocate the system functions. (Norman P. Geis, 1991)
  - P Use open architectures.You will need them once the market starts to respond.

Multitask Heuristics /8

- P Plan to throw one away. You will anyway. (F. P. Brooks, Jr., 1982)
  - P You can't avoid redesign. It's a natural part of design.
- P Don't make an architecture too smart for its own good.
- D Amid a wash of paper, a small number of documents become critical pivots around which every project's management revolves. (F. P. Brooks, Jr., 1982)
  - P Just because it's written, doesn't make it so. (Susan Ruth, 1993)
- D In architecting a new [software] program all the serious mistakes are made in the first day. [Spinrad, 1988]
  - P The most dangerous assumptions are the unstated ones. (Douglas R. King, 1991)
  - D Some of the worst failures are systems failures.

Multitask Heuristics /9

- D In architecting a new [aerospace] system, by the time of the first design review, performance, cost, and schedule have been predetermined. One might not know what they are yet, but to first order all the critical assumptions and choices have been made which will determine those key parameters.
- Work forward and backward. (A set of heuristics from Rubinstein, 1975.)
  - Generalize or specialize.
  - Explore multiple directions based on partial evidence.
  - Form stable substructures.
  - Use analogies and metaphors.
  - Follow your emotions.
- P Try to hit a solution that, at worst, won't put you out of business. (Bill Butterworth as reported by Laura Noel, 1991)
- P The order in which decisions are made can change the architecture as much as the decisions themselves. (Rechtin, 1975, IEEE SPECTRUM)

Multitask Heuristics /10

- P Don't assume that the original statement of the problem is necessarily the best, or even the right, one.
  - P Extreme requirements, expectations, and predictions should remain under challenge throughout system design, implementation, and operation.
  - P Any extreme requirement must be intrinsic to the system's design philosophy and must validate its selection. "Everything must pay its way on to the airplane." [Harry Hillaker, 1993]
  - P Don't assume that previous studies are necessarily complete, current or even correct. (James Kaplan, 1992)
  - P Challenge the process and solution, for surely someone else will do so. (Kenneth L. Cureton, 1991)
  - P Just because it worked in the past there's no guarantee that it will work now or in the future. (Kenneth L. Cureton, 1991)
  - P Explore the situation from more than one point of view. A seemingly impossible situation might suddenly become transparently simple. (Christopher Abts, 1988)

Multitask Heuristics /11

- P Build in and maintain options as long as possible in the design and build of complex systems. You will need them. OR...Hang on to the agony of decision as long as possible. [Robert Spinrad, 1988]
  - P Successful architectures are proprietary, but open. [Morrison and Ferguson, 1993]
- D Once the architecture begins to take shape, the sooner contextual constraints and sanity checks are made on assumptions and require- ments, the better.
- D Concept formulation is complete when the builder thinks the system can be built to the client's satisfaction.
- D The realities at the end of the conceptual phase are not the models but the acceptance criteria.
- P Do the hard parts first.
- P Firm commitments are best made after the prototype works.

Modeling

- P If you can't analyze it, don't build it.
- D Modeling is a craft and at times an art. (William C. Burkett, 1994)
- D A vision is an imaginary architecture...no better, no worse than the rest of the models. (M. B. Renton, Spring, 1995)
- D From psychology: if the concepts in the mind of one person are very different from those in the mind of the other, there is no common model of the topic and no communication. [Taylor, 1975] OR... From telecommunications: The best receiver is one that contains an internal model of the transmitter and the channel. [Robert Parks and Frank Lehan, 1954]
- D A model is not reality.
  - D The map is not the territory. (Douglas R. King, 1991)
  - P Build reality checks into model-driven development. [Larry Dumas, 1989]
  - P Don't believe nth order consequences of a first order [cost] model. [R. W. Jensen, circa 1989]

Modeling /2

- D Constants aren't and variables don't. (William C. Burkett, 1992)
- D One insight is worth a thousand analyses. (Charles W. Sooter, 1993)
  - P Any war game, systems analysis, or study whose results can't easily be explained on the back of an envelope is not just worthless, it is probably dangerous. [Brookner-Fowler, circa 1988]
- D Users develop mental models of systems based [primarily] upon the user-to-system interface. (Jeffrey H. Schmidt)
- D If you can't explain it in five minutes, either you don't understand it or it doesn't work. (Darcy McGinn, 1992 from David Jones)
- P The eye is a fine architect. Believe it. [von Braun, 1950]
- D A good solution somehow looks nice. (Spinrad, 1991)
  - P Taste: an aesthetic feeling which will accept a solution as right only when no more direct or simple approach can be envisaged. [Robert Spinrad, 1994]
  - P Regarding intuition, trust but verify. (Jonathan Losk, 1989)

Prioritizing (trades, options, and choices)

- D In any resource-llimited situation, the true value of a given service or product is determined by what one is willling to give up to obtain it.
- P When choices must be made with unavoidably inadequate information, choose the best available and then watch to see whether future solutions appear faster than future problems. If so, the choice was at least adequate. If not, go back and choose again.
- P When a decision makes sense through several different frames, it's probably a good decision. (J. E. Russo, 1989)
- D The choice between architectures may well depend upon which set of drawbacks the client can handle best.

Prioritizing (trades, options, and choices /2)

- P If trade results are inconclusive, then the wrong selection criteria were used. Find out [again] what the customer wants and why they want it, then repeat the trade using those factors as the [new] selection criteria. (K. Cureton, 1991)
- P The triage: Let the dying die. Ignore those who will recover on their own. And treat only those who would die without help.
- P Every once in a while you have to go back and see what the real world is telling you. [Harry Hillaker, 1993]

Aggregating

- P Group elements that are strongly related to each other, separate ele- ments that are unrelated.
- D Many of the requirements can be brought together to complement each other in the total design solution. Obviously the more the design is put together in this manner, the more probable the overall success. (J. E. Steiner, 1978)
- P Subsystem interfaces should be drawn so that each subsystem can be implemented independently of the specific implementation of the subsystems to which it interfaces. (Mark Maier, 1988)
- P Choose a configuration with minimal communications between the subsystems. (computer networks)
  - P Choose the elements so that they are as independent as possible; that is, elements with low external complexity (low coupling) and high internal complexity (high cohesion). (Christopher Alexander, 1964 modified by Jeff Gold, 1991)
  - P Choose a configuration in which local activity is high speed and global activity is slow change. (Courtois, 1985)

Aggregating /2

- P Poor aggregation results in gray boundaries and red performance.
  - P Never aggregate systems that have a conflict of interest; partition them to ensure checks and balances. (Aubrey Bout, 1993)
  - P Aggregate around "testable" subunits of the product; partition around logical subassemblies. (Ray Cavola, 1993)
  - P Iterate the partition/aggregation procedure until a model consisting of 7 ± 2 chunks emerge. (M. F. Rubinstein, 1975)
  - P The optimum number of architectural elements is the amount that leads to distinct action, not general planning.
- P System structure should resemble functional structure.
  - P Except for good and sufficient reasons, functional and physical structuring should match.
  - P The architecture of a support element must fit that of the system which it supports. It is easier to match a support system to the human it supports than the reverse.
- Unbounded limits on element behavior may be a trap in unexpected scenarios. [Bernard Kuchta, 1989]

Partitioning

- Do not slice through regions where high rates of information exchange are required. (computer design)
- D The greatest leverage in architecting is at the interfaces.
  - P Guidelines for a good quality interface specification: they must be simple, unambiguous, complete, concise, and focus on substance. Working documents should be the same as customer deliverables; that is, always use the customer's language, not engineering jargon. [Harry Hillaker, 1993]
  - P The efficient architect, using contextual sense, continually looks for likely misfits and redesigns the architecture so as to eliminate or minimize them. (Christopher Alexander, 1964) It is inadequate to architect up to the boundaries or interfaces of a system; one must architect across them. (Robert Spinrad, as reported by Susan Ruth, 1993)
  - P Since boundaries are inherently limiting, look for solutions outside the boundaries. (Steven Wolf, 1992)
  - P Be prepared for reality to add a few interfaces of its own

Partitioning /2

- P Design the structure with good “bones.”
- Organize personnel tasks to minimize the time individuals spend interfacing. (Tausworthe, 1988)

Integrating

- Relationships among the elements are what give systems their added value.
  - P The greatest leverage in system architecting is at the interfaces.
  - P The greatest dangers are also at the interfaces. [Raymond, 1988]
  - P Be sure to ask the question: "What is the worst thing that other elements could do to you across the interface?
- D Just as a piece and its template must match, so must a system and the resources which make, test, and operate it; or, more briefly, the product and process must match. Or, by extension, a system archi- tecture cannot be considered complete lacking a suitable match with the process architecture.
  - P When confronted with a particularly difficult interface, try changing its characterization.
- P Contain excess energy as close to the source as possible.
  - P Place barriers in the paths between energy sources and the ele- ments the energy can damage. (Kjos, 1988)

Certifying (system integrity, quality and vision

- D As time to delivery decreases, the threat to functionality increases. (Steven Wolf, 1992)
  - P If it is a good design, insure that it stays sold. (Dianna Sammons, 1991)
- D Regardless of what has gone before, the acceptance criteria determine what is actually built.
  - D The number of defects remaining in a (software) system after a given level of test or review (design review, unit test, system test, etc.) is proportional to the number found during that test or review.
  - P Tally the defects, analyze them, trace them to the source, make corrections, keep a record of what happens afterward, and keep repeating it.
  - P Discipline. Discipline. Discipline. (Douglas R. King, 1991)
  - P The principles of minimum communications and proper partitioning are key to system testability and fault isolation.
  - P The five whys of Toyota's lean manufacturing. (To find the basic cause of a defect, keep asking "why" from effect to cause to cause five times.)

Certifying (system integrity, quality and vision /2

- D The test setup for a system is itself a system.
  - P The test system should always allow a part to pass or fail on its own merit. [James Liston, 1991]
  - P To be tested, a system must be designed to be tested.
- D An element "good enough" in a small system is unlikely to be good enough in a more complex one.
- D Within the same class of products and processes, the failure rate of a product is linearly proportional to its cost.
- D The cost to find and fix an inadequate or failed part increases by an order of magnitude as it is successively incorporated into higher levels in the system.
  - P The least expensive and most effective place to find and fix a problem is at its source.
- D Knowing a failure has occurred is more important than the actual failure. (Kjos, 1988)
- D Mistakes are understandable, failing to report them is inexcusable.

Certifying (system integrity, quality and vision /3

- D Recovery from failure or flaw is not complete until a specific mechanism, and no other, has been shown to be the cause.
- D Reducing failure rate by each factor of two takes as much effort as the original development.
- D Quality can't be tested in, it has to be built in.
  - D You can't achieve quality... unless you specify it. (Deutsch, 1988)
  - P Verify the quality close to the source. (Jim Burruss, 1993)
  - P The five whys of Japan's lean manufacturing.
  - D High quality, reliable systems are produced by high quality architecting, engineering, design, and manufacture, not by inspection, test, and rework.
  - P Everyone in the development and production line is both a customer and a supplier.
- D Next to interfaces, the greatest leverage in architecting is in aiding the recovery from, or exploitation of, deviations in system performance, cost, or schedule.

Assessing Performance, Cost, Schedule, and Risk

- D A good design has benefits in more than one area. (Trudy Benjamin, 1993)
- D System quality is defined in terms of customer satisfaction, not re- quirements satisfaction. (Jeffrey Schmidt, 1993)
- D If you think your design is perfect, it's only because you haven't shown it to someone else. [Harry Hillaker, 1993]
  - P Before proceeding too far, pause and reflect. Cool off periodically and seek an independent review. (Douglas R. King, 1991)
- D Qualification and acceptance tests must be both definitive and passable.
  - P High confidence, not test completion, is the goal of successful qualification. (Daniel Gaudet, 1991)
  - P Before ordering a test decide what you will do if it is: (I) positive or (2) it is negative. If both answers are the same, don't do the test. (R. Matz, M. D., 1977)
- D "Proven" and "state of the art" are mutually exclusive qualities. (Lori I. Gradous, 1993)

Assessing Performance, Cost, Schedule, and Risk /2

- D The bitterness of poor performance remains long after the sweetness of low prices and prompt delivery are forgotten. (Jerry Lim, 1994)
- D The reverse of diagnostic techniques are good architectures. (M.B. Renton, 1995)
- D Unless everyone who needs to know does know, somebody, some- where will foul up.
  - P Because there's no such thing as immaculate communication, don't ever stop talking about the system. (Losk, 1989)
- D Before it's tried, it's opinion. After it's tried, it's obvious. (William C. Burkett, 1992)
- D Before the war it's opinion. After the war, it's too late! (Anthony Cerveny, 1991)
- D The first quick look analyses are often wrong.

Assessing Performance, Cost, Schedule, and Risk /3

- D In correcting system deviations and failures it is important that all the participants know not only what happened and how it happened, but why as well.
  - P Failure reporting without a close out system is meaningless. (April Gillam, 1989)
  - P Common , if undesirable, responses to indeterminate outcomes or failures:
    - If it ain't broke, don't fix it.
    - Let's wait and see if it goes away or happens again.
    - It was just a random failure. One of those things.
    - Just treat the symptom. Worry about the cause later.
    - Fix everything that might have caused the problem.
    - Your guess is as good as mine.
- D Chances for recovery from a single failure or flaw, even with complex consequences, are fairly good. Recovery from two or more independent failures is unlikely in real-time and uncertain in any case.

Rearchitecting, Evolving, Modifying and Adapting

- D The test of a good architecture is that it will last. The sound architecture is an enduring pattern.
- P The team that created and built a presently successful product is often the best one for its evolution — but seldom for creating its replacement.
- D If you don't understand the existing system, you can't be sure you're re-architecting a better one.
- P When implementing a change, keep some elements constant to provide an anchor point for people to cling to.
  - P In large, mature systems, evolution should be a process of ingress and egress.
  - P Before the change, it is your opinion. After the change it is your problem.
- D Unless constrained, re-architecting has a natural tendency to proceed unchecked until it results in a substantial transformation of the system.
- D Given a change, if the anticipated actions don't occur, then there is probably an invisible barrier to be identified and overcome.