Agile Applied Research for Cybersecurity

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Definition of Research

Research is what I'm doing when I don't know what I'm doing.

— Wernher von Braun

Research Gap

- Traditional research aimed at developing, understanding, applying foundational work
- But sometimes problems require
  - Short term research leading into …
  - Better understanding of the problem
  - Results that can be applied quickly
  - What long-term research would be most useful and interesting to deal with the problem over the long term

Agile Research

- Exploratory research where speed is overarching requirement
- Contribution: merge
  - Exploratory methods that focus on applied research
  - Academic, broader methods that focus on foundational research

Innovation

- Institutions produce technical change via research and development
- Institutions are places *and social roles*
- Innovations change both social roles of these places and social rules by which they interact
  - Example: Bayh-Dole Act (1980)

Agile Research Basis

- Sponsors pose research questions
- Researchers carry out the research and produce results
- Done iteratively, and with sponsors able to reframe the direction of the research if needed

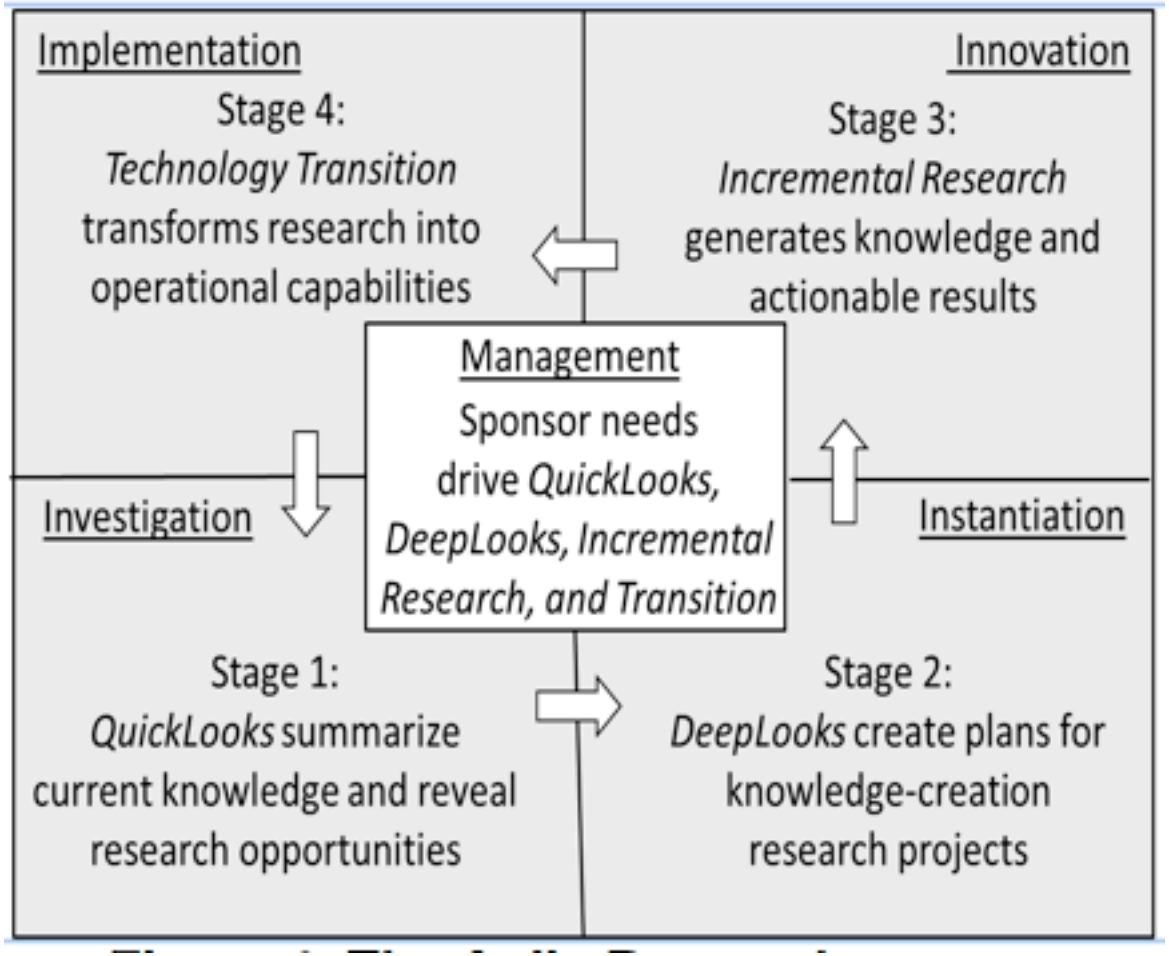
Agile Research Principles

- **Predefined Infrastructure**: resources, logistics defined and allocated *before* research needs emerge
- **Incremental Research**: structured into iterative, short-term, accumulating increments each producing something of value to sponsor

Agile Research Principles

- **Incremental management**: process provides built-in, short-term checkpoints for sponsors to understand research, redirect if needed based on incremental results
- **Transferability**: one group may carry out research, but must do so in a way that allows the current state to be transferred to another group if necessary

Agile Research Process



Agile Research Properties

- Flexible
- Anticipatory
- Staged
- Speedy
- Visible
- Effective
- Impactful
- Incremental

Example: Data Tagging

- Problem: use data tagging to support access and retention policies
- Research questions from QuickLook Study:
  - Examine current use of data tagging for ABAC, with policy-based attributes and tags used for a large enterprise
  - Identify technologies that can be adapted to data tagging needs
  - Research how to use data tagging to support access, retention policies
  - Identify other relevant research objectives

Data Tagging Way Forward: Recommendations

- Define a path forward in light of the complexity of the problem
  - Organize complexity of problem using structured, divide and conquer refinement of goals and requirements
  - Explore existing data tagging solution space for cost-effective application to the problem set to address sponsor needs
- Conduct incremental research and development.
  - Research tag representation and management as foundation for information sharing
  - Develop proof of concept system to explore and evaluate potential solutions

Data Tagging Solution Space: Recommendations

- There are promising existing commercial solutions.
  - Run public challenge for data tagging to elicit potential solutions
  - Conduct data tagging product evaluations
- Sponsor organization is beginning to pilot solutions for enterprise data tagging in several areas
  - Study data tagging design patterns of sponsor organization
- Other organizations beginning to tackle enterprise data tagging
  - Evaluate design patterns used in sponsor organization
  - Investigate an earlier sponsor organization information discovery and assured access study

Data Tagging Requirements Analysis: Recommendations

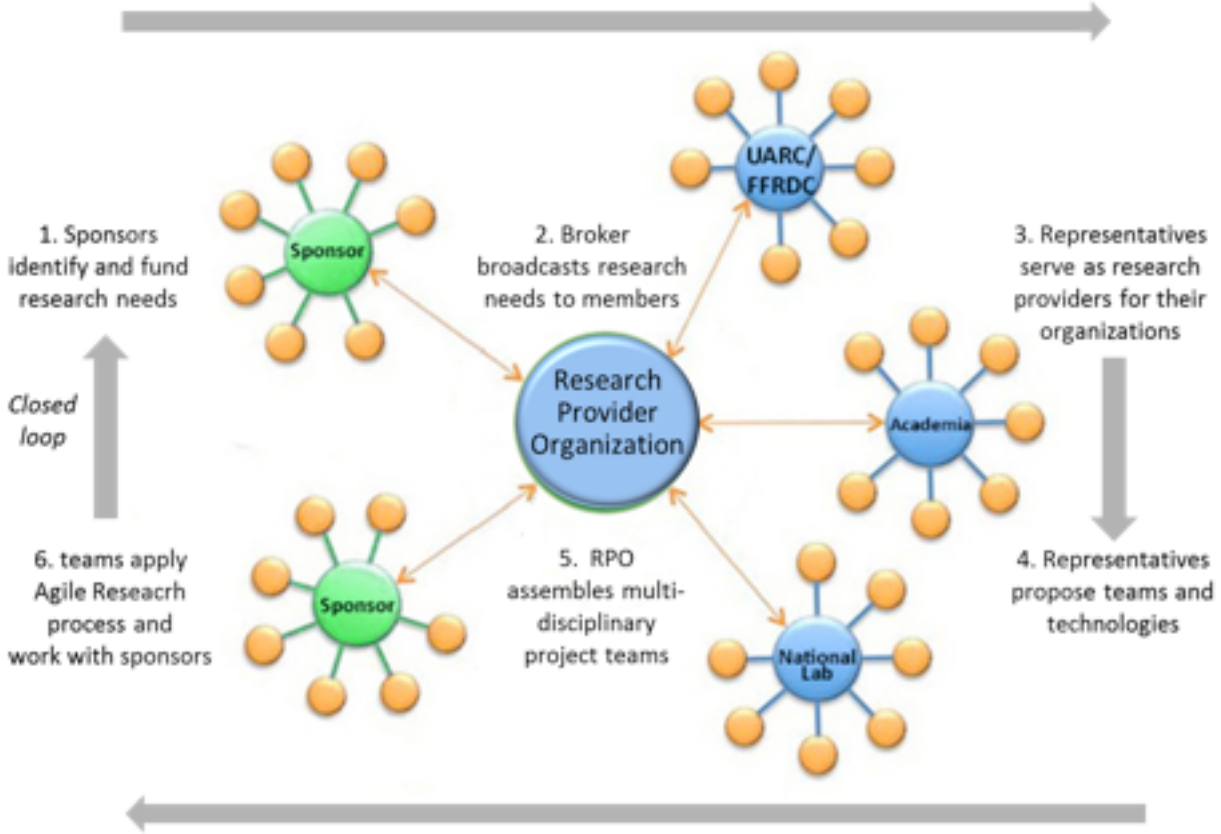
- Problem domain too complex to tackle with traditional requirements specification
  - Conduct structured engineering assessment to define incremental development, deployment stages
- Information architecture needed for data tags
  - Develop a data tagging Concept of Operations
  - Conduct an organizational inventory of attribute data
  - Assess taxonomies, ontologies for representing tags.
  - Conduct study of trade-offs between tagging data at rest and on the fly

Data Tagging Requirements Analysis: Recommendations

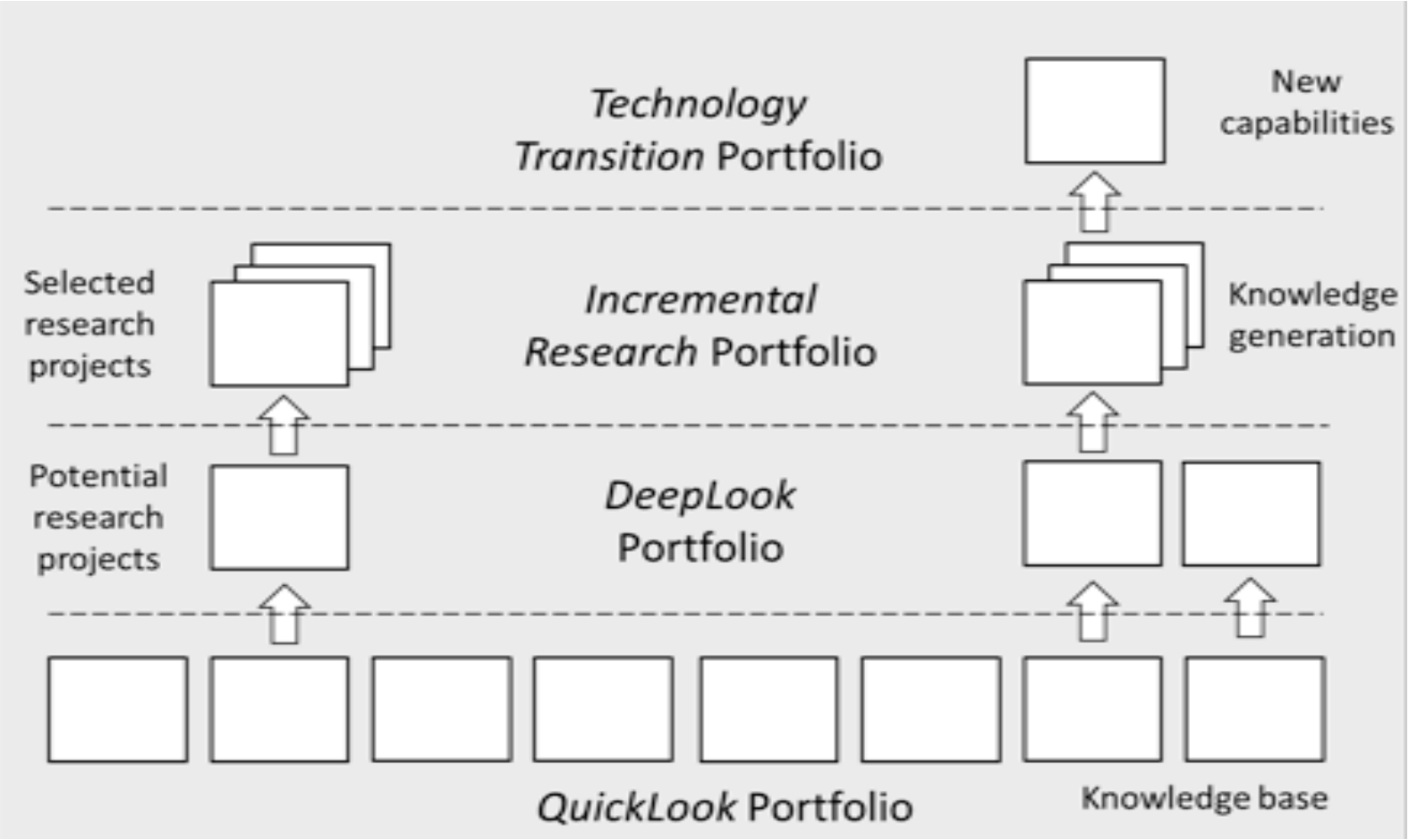
- Tagging technologies, mechanisms must be secured.
  - Identify potential threats and vulnerabilities.
  - Develop security reference architectures for data tagging
  - Assess efficacy of Identity-Based Internet Protocol (IBIP) to secure data tagging network

Lots of grist for DeepLook Step! Also suggests several foundational research questions

Agile Research Structure



Agile Research Portfolio



INSuRE Project

- Focal activity: cybersecurity research class
  - INSuRE stands for INformation Security Research and Education
- Sponsors propose problems
  - If selected, sponsor expected to provide guidance, feedback students in conjunction with faculty
  - Sponsor must agree that, if results merit publication, the research can be published
    - So far, no problems with doing this

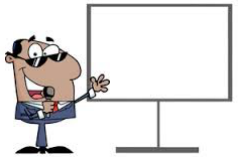
Overview of Structure

1. Project bid
2. Project proposal
3. Literature review
4. Progress report and presentation
5. Final report, presentation for schools on semester system
   - Penultimate report, presentation for quarter system
6. Final report, presentation for schools on quarter system

Set-Up

- Faculty solicit research proposals from (potential) sponsors
  - Typically, a paragraph describing problem in general terms
  - Examples
    - Identifying ICS components in a network
    - Code variation as a defense against attacks
    - Analysis of proposed TCPcrypt protocol

- Sponsors then "pitch" the projects to the students in first 1 or 2 class meetings



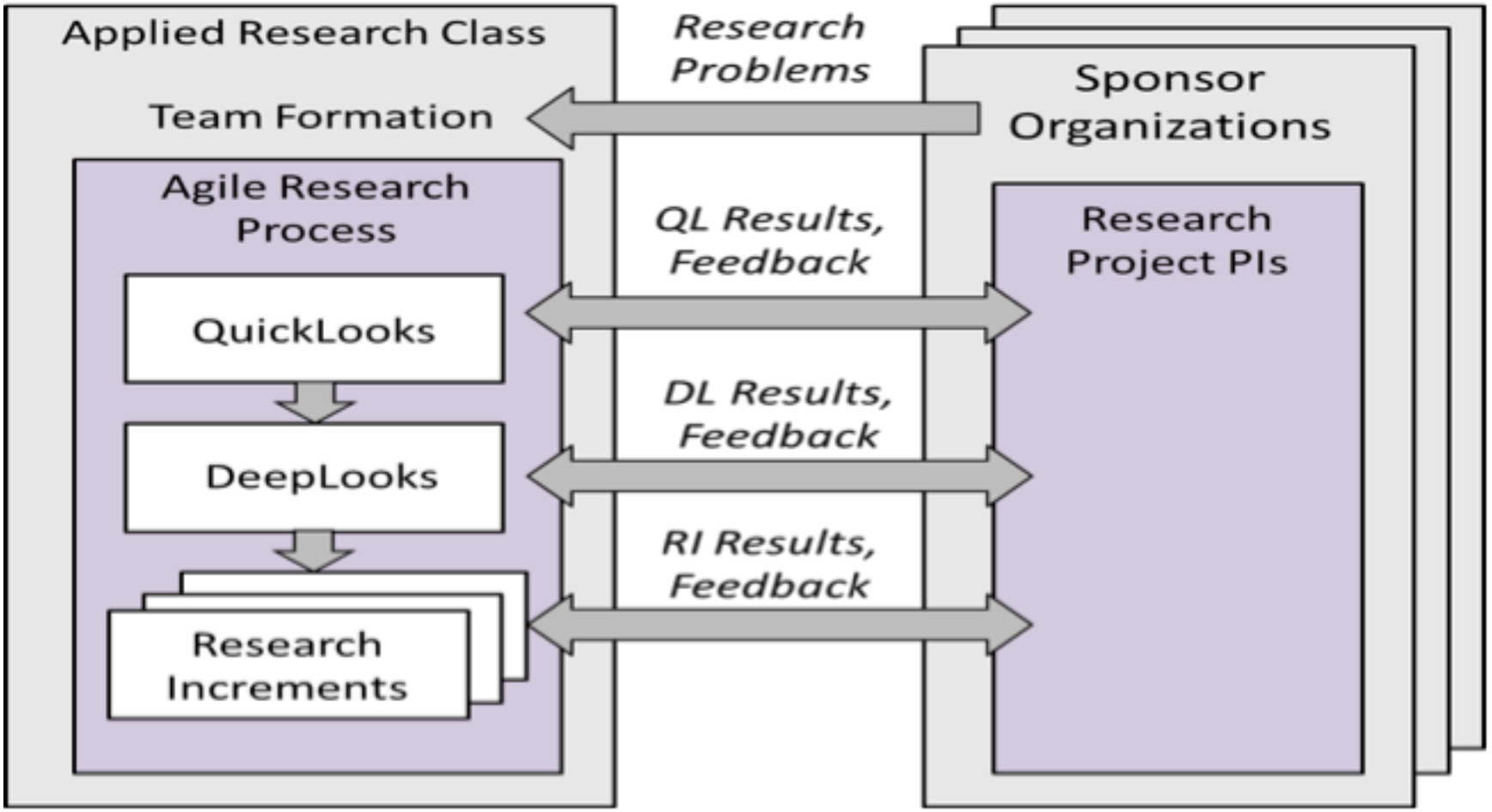
Research

- Students meet weekly with sponsor, faculty to report progress, challenges encountered and overcome, next week's goals
- Goals may change based on challenges found
  - Allow sponsors to modify incremental research goals
  - Sponsors can apply intermediate results as work progresses
  - Students see their work being used

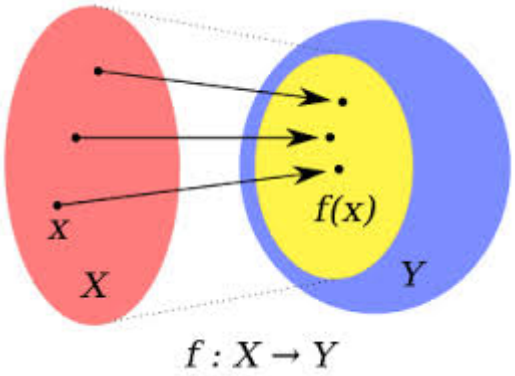
Reports

- Weekly progress reports
- Midterm progress report
  - Delivered as formal paper, presentation to all participating teams
- Final report
  - Also delivered to all teams
- Critical idea: document results, tools, datasets so that another team can pick up where this team left off
  - Teaches data curation

Putting It Together



Mapping



- Bid, proposal ➔ QuickLook
  - Difference: students don't identify subject matter experts; instead, explain why they should be considered (or will become) experts
- Proposal preparation ➔ DeepLook
  - Presents goals, what the research plan can be expected to accomplish
- Research ➔ Incremental Research Stage
  - Weekly meetings allow sponsor to adjust goals of research to meet needs, and based on weekly outcomes

Questions

- How to determine when to use Agile Research rather than (or in addition to) long-term research
- How to develop intermediate goals so that:
  - Incremental results are useful
  - Incremental results will enable the sponsor to provide further guidance to the research group
  - Incremental goals will provide insight into the foundational research necessary to provide deeper understanding of the problem and, possibly, long-term solutions (this, especially in an academic setting)

Conclusion

- Long-term research questions arise from Agile Research projects
  - Agile Research is applied research towards a particular, pressing end
  - Thus, ideal for identifying interesting long-term research projects
- Agile Research exhibits properties that are critical to research involvement in the fast paced and unpredictable world of cybersecurity

Closing Thought

- To those accustomed to the precise, structured methods of conventional system development, exploratory development techniques may seem messy, inelegant, and unsatisfying. But it's a question of congruence: precision and flexibility may be just as dysfunctional in novel, uncertain situations as sloppiness and vacillation are in familiar, well-defined ones. Those who admire the massive, rigid bone structures of dinosaurs should remember that jellyfish still enjoy their very secure ecological niche.

  — Beau Sheil, "Power Tools for Programmers"