# Why and How we do research

**Prasad Calyam, Ph.D.**

*Spring 2015*

# VIMAN Lab Cloud Computing Research
http://people.cs.missouri.edu/~calyamp



- Cloud Resource Allocation
  - Computer and network virtualization models, algorithms, tools
- Cloud Monitoring
  - Software-defined measurements and performance diagnosis
- Cloud Testbeds for Apps, Marketplaces
  - e.g., Manufacturing/Healthcare/Education
- Cloud Security
  - Cyber attacks, Authentication, Authorization, Policy

# Discussion Topics

- Importance of Research
  - Technology advances and society benefits
  - Research as highest level of learning
- Understanding Research Process
  - Fundamental research to Commercialization
- Best Practices
  - VIMAN Lab methodology
  - Research Writing/Speaking
- Conclusion

# Discussion Topics

- Importance of Research
  - Technology advances and society benefits
  - Research as highest level of learning
- Understanding Research Process
  - Fundamental research to Commercialization
- Best Practices
  - VIMAN Lab methodology
  - Research Writing/Speaking
- Conclusion

# Research shapes technology in society!
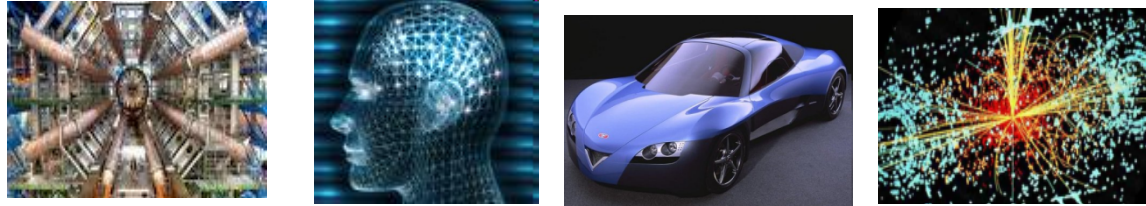


*Science and Technical Applications*



*Business Applications*



*Consumer/Social Applications*

# Bloom's Taxonomy

Research activities help students practice highest levels of learning!

**Remembering:** can the student recall or remember the information?
*define, duplicate, list, memorize, recall, repeat, reproduce state*

**Understanding:** can the student explain ideas or concepts?
*classify, describe, discuss, explain, identify, report, select, translate, paraphrase*
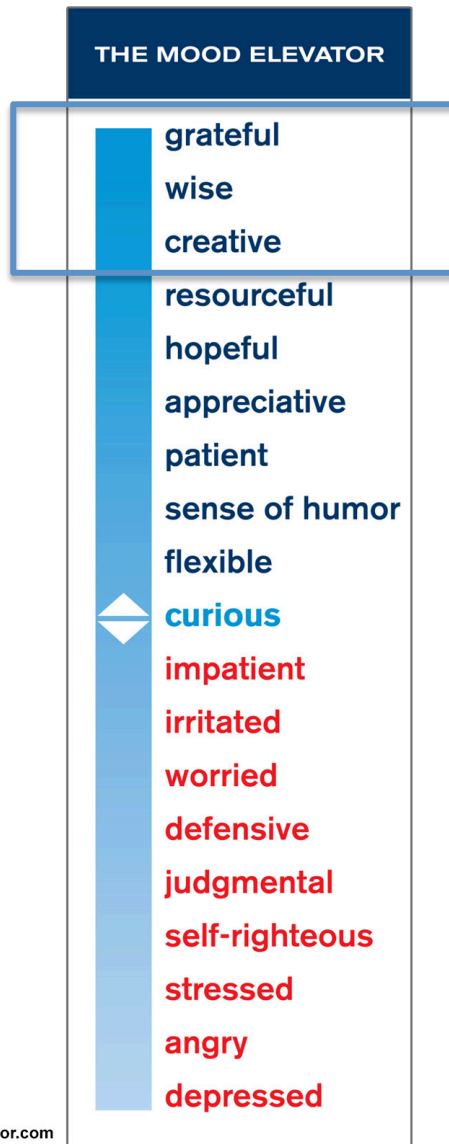
......

**Evaluating**: can the student justify a stand or decision?
*appraise, argue, defend, judge, select, support, value, evaluate*

**Creating**: can the student create new product or point of view?
*assemble, construct, create, design, develop, formulate, write*

# Besides, Research makes you happy! ☺



**THE MOOD ELEVATOR**

- grateful
- wise
- creative
- resourceful
- hopeful
- appreciative
- patient
- sense of humor
- flexible
- curious
- impatient
- irritated
- worried
- defensive
- judgmental
- self-righteous
- stressed
- angry
- depressed

Get the book at:
www.upthemoodelevator.com

# Discussion Topics

- Importance of Research
  - Technology advances and society benefits
  - Research as highest level of learning
- **Understanding Research Process**
  - Fundamental research to Commercialization
- Best Practices
  - VIMAN Lab methodology
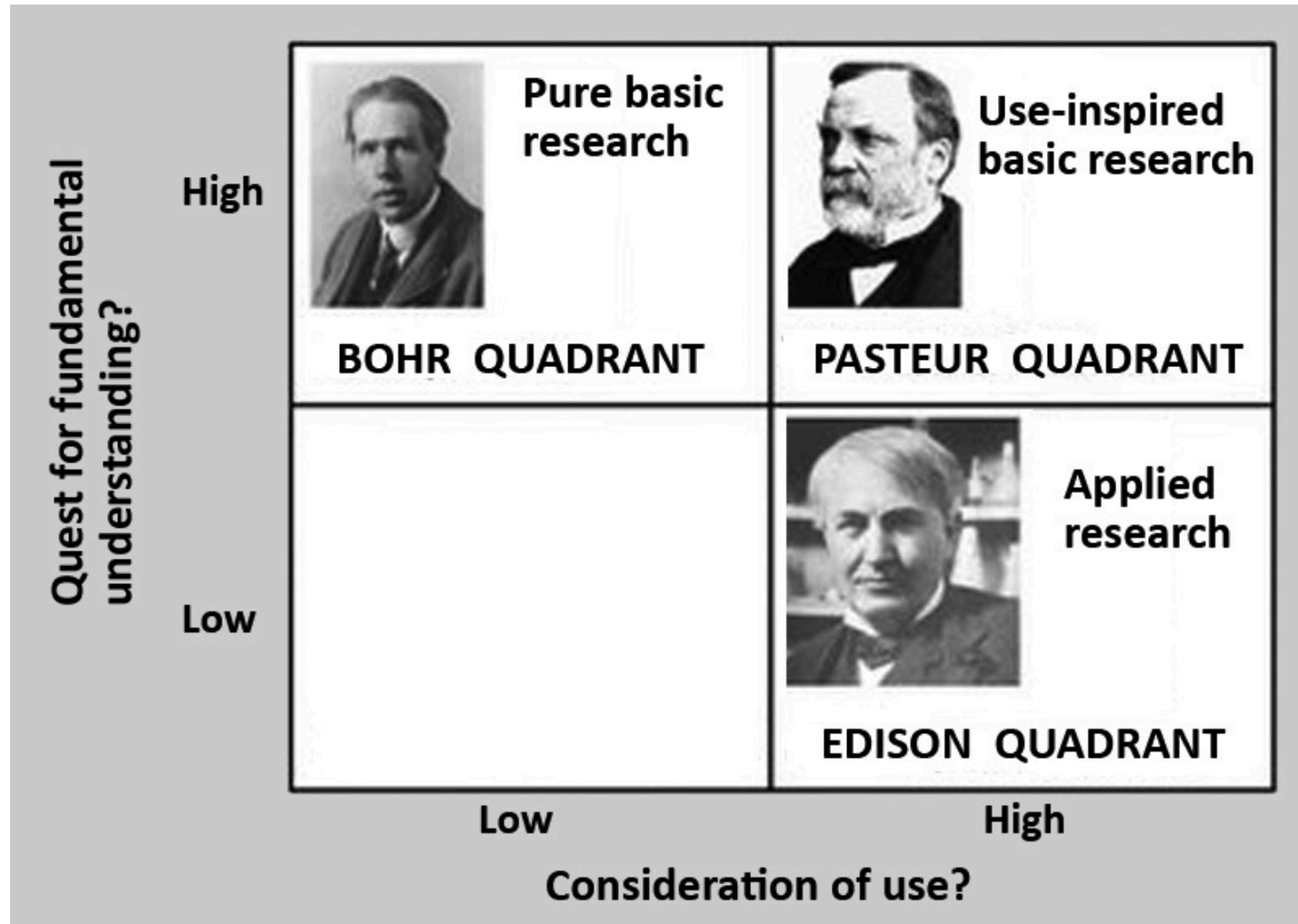  - Research Writing/Speaking
- Conclusion

# So what is involved in research?

NOTE: Bottom half of original comic (THE ACTUAL METHOD) not shown for obvious reasons… ☺
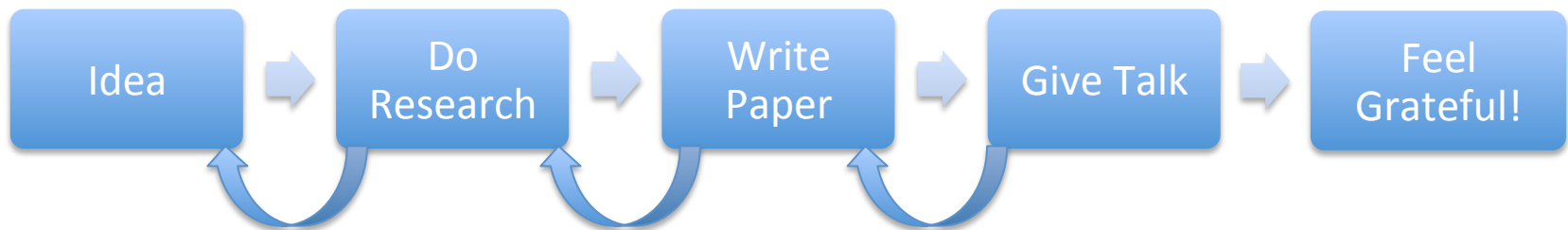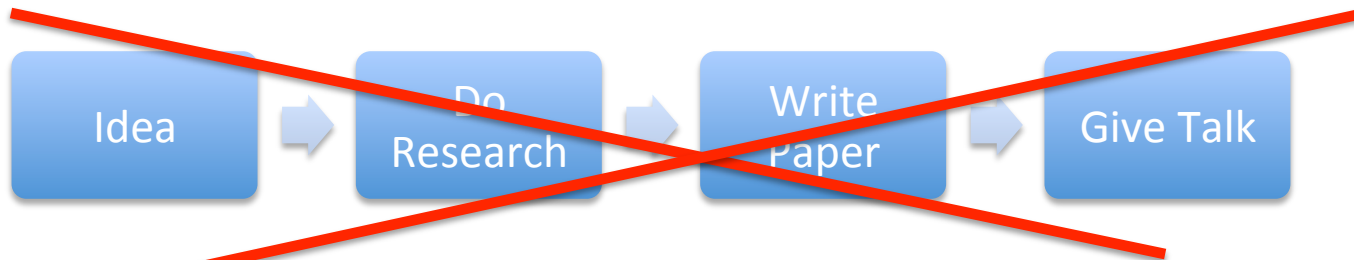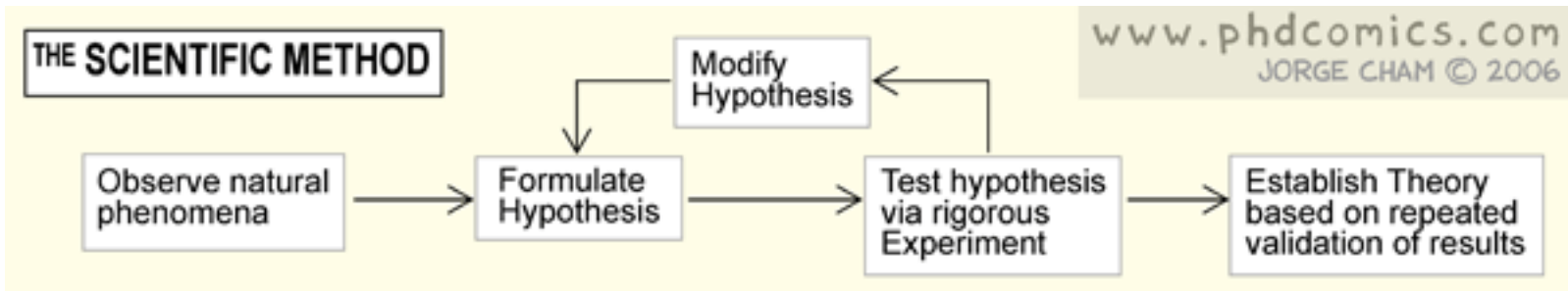
# Basic versus Applied Research
## "Pasteur's Quadrant"

# Basic versus Applied Research "Pasteur's Quadrant"

| | **Search for new understanding** | **Apply existing knowledge** |
|---|---|---|
| **Aimed at some practical problem** | Pasteur: fundamental research aimed at solving important applied problems | Inventors such as Thomas Edison fit the quadrant of searching for relevant knowledge to solve an applied problem, but without any attempt to expand our general understanding of phenomena |
| **Pure science. No application in mind** | Researchers most often play in the fun quadrant, finding lovely problems to work on without regard for whether anyone cares outside of their fellow research in-group | A third quadrant is filled with tinkerers who produce inventions that neither add to fundamental understanding nor have any use |

Applicability (vertical axis)

Knowledge (horizontal axis)
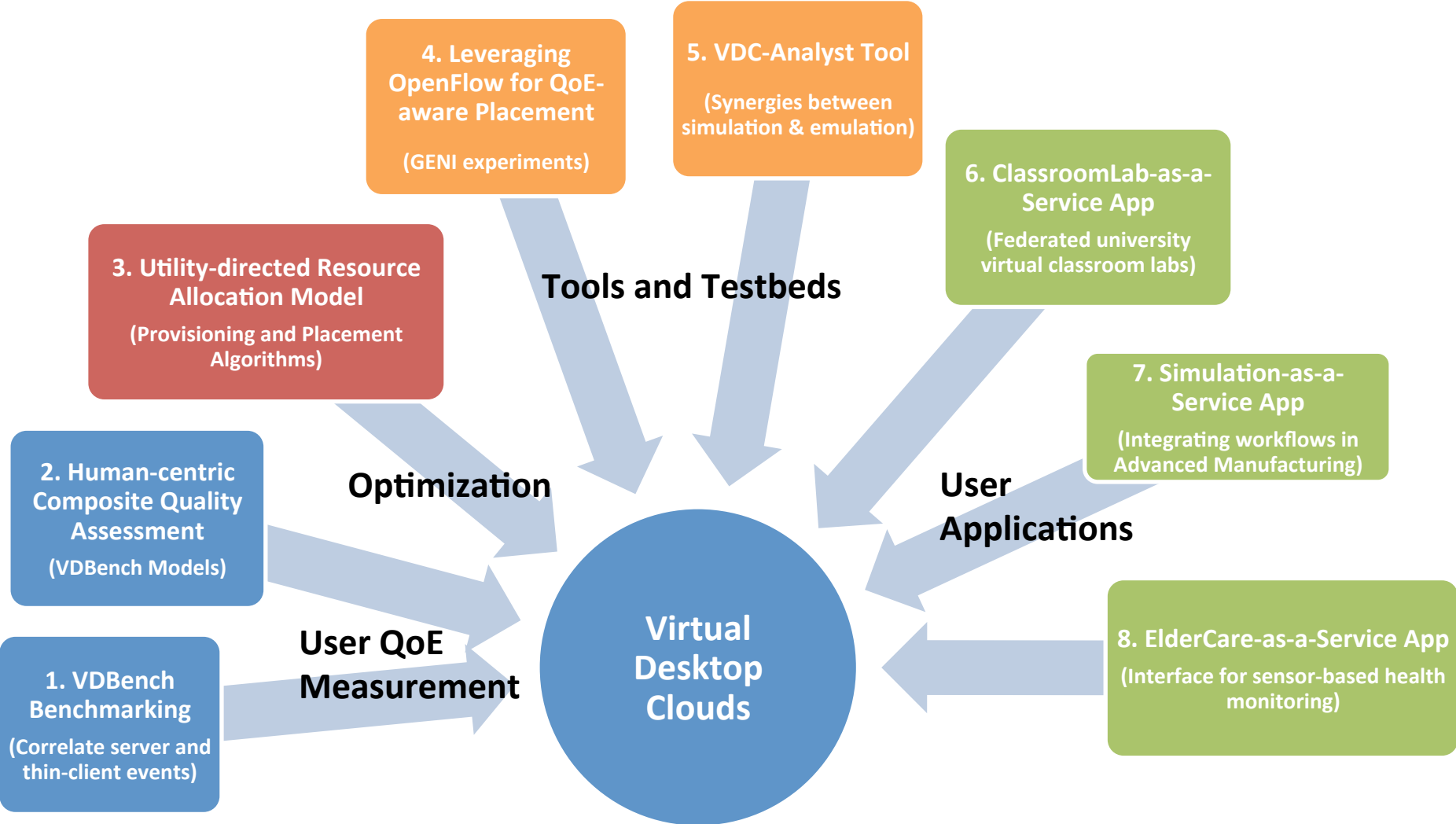
# Where can research lead to?
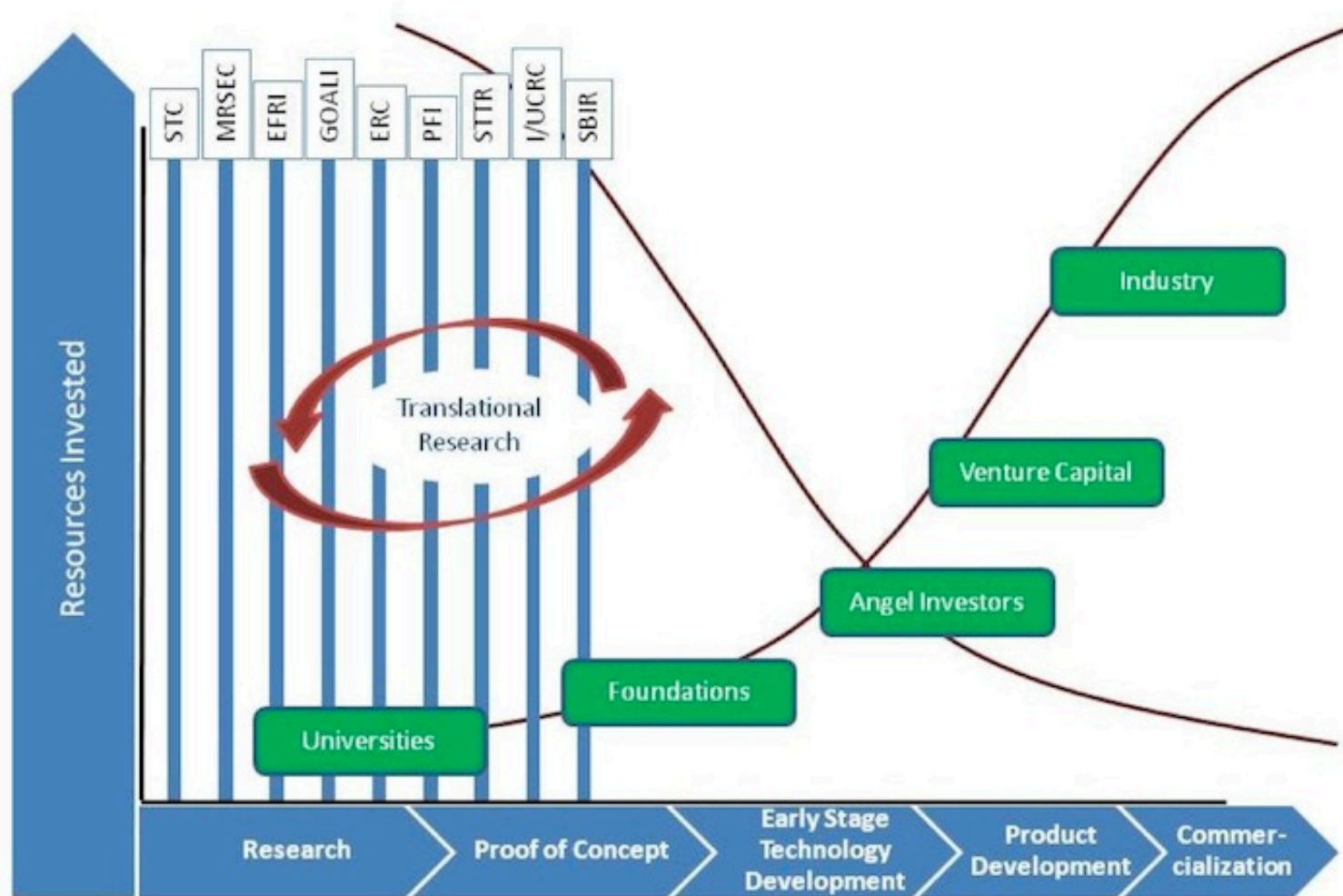
# My R&D Impact
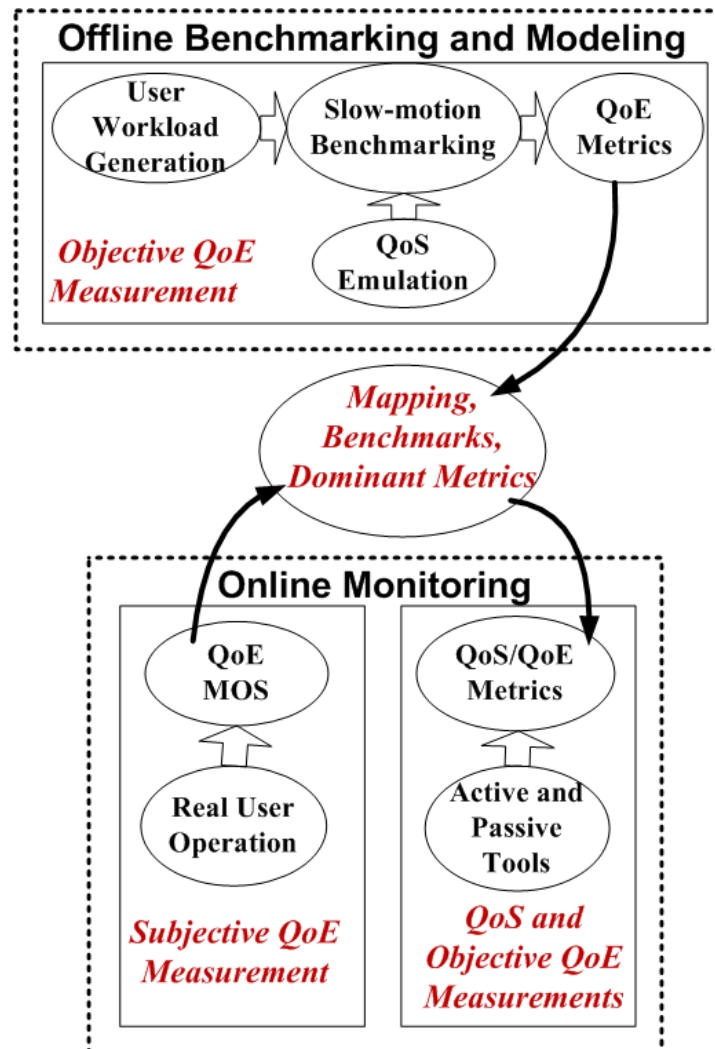## (@ State, National and International levels)

- Models and Algorithms
  - *User QoE Models:* User's audiovisual quality experience estimation based on network health and content characteristics
    - Used in product development at Huawei Technologies and Apparent Networks
  - *OnTimeDetect:* Network anomaly detection algorithms
    - Used in DOE community for monitoring networks with large data movements (e.g., LHC)
  - *OnTimeSample:* Multi-domain network measurements orchestration algorithms
    - Multiple derivative works by other reputed researchers at NJIT, Purdue U, Iowa State U
    - Selected by DOE for technology commercialization through their STTR program

- Tools
  - *H.323 Beacon:* Videoconference performance troubleshooting tool
    - ~45,000 downloads on sf.net since 2003; Tool promoted by Internet2 Commons, Polycom
  - *OnTimeMeasure:* Instrumentation and measurement of Cloud systems
    - Top software pick by GENI Project Office for a sustainability study
  - *DISC:* Enables import, storage and collaboration of OSC users' research data
    - New service at OSC attracting OSU Medical Center user communities

- CyberInfrastructures
  - *RICE:* Environment for remote access of computer-controlled instruments
    - Used @ OSU Chemistry, featured on OSU Home Page, PC Magazine, CPU Magazine
  - *VMLab:* Thin-client based Cloud computing testbed
    - Has enabled development of new OARnet/OSC cloud-services and a research program at OSU and MU; could lead to new cyberinfrastructure services at MU soon…

# Desktop-to-Cloud Research "Program" Example



**4. Leveraging OpenFlow for QoE-aware Placement**

(GENI experiments)

**5. VDC-Analyst Tool**

(Synergies between simulation & emulation)

**6. ClassroomLab-as-a-Service App**

(Federated university virtual classroom labs)

**3. Utility-directed Resource Allocation Model**

(Provisioning and Placement Algorithms)

**Tools and Testbeds**

**7. Simulation-as-a-Service App**

(Integrating workflows in Advanced Manufacturing)

**2. Human-centric Composite Quality Assessment**

(VDBench Models)

**Optimization**

**User Applications**

**1. VDBench Benchmarking**

(Correlate server and thin-client events)

**User QoE Measurement**

**Virtual Desktop Clouds**

**8. ElderCare-as-a-Service App**

(Interface for sensor-based health monitoring)

Sponsors: NSF, VMware, Dell, IBM, Raytheon-BBN, Mozilla

# Research "Project" Methodology Example

Y. Xu, P. Calyam, D. Welling, S. Mohan, A. Berryman, R. Ramnath, "Human-centric Composite Quality Modeling and Assessment for Virtual Desktop Clouds", ZTE Communications Journal - Special Issue on QoE Modeling and Applications for Multimedia Systems, 2013.

# Discussion Topics

- Importance of Research
  - Technology advances and society benefits
  - Research as highest level of learning
- Understanding Research Process
  - Fundamental research to Commercialization
- Best Practices
  - VIMAN Lab methodology
  - Research Writing/Speaking
- Conclusion

# Research starts with a Proposal!
## Heilmeier's Catechism

- What are you trying to do? Articulate your objectives using absolutely no jargon.
- How is it done today, and what are the limits of current practice?
- What's new in your approach and why do you think it will be successful?
- Who cares? If you're successful, what difference will it make?
- What are the risks and the payoffs?
- How much will it cost? How long will it take?
- What are the midterm and final "exams" to check for success?

# Research Work @ VIMAN Lab

**"Motivated Students + Adviser Inspiration = Great Research!"**
**"Freedom, Responsibility & Accountability"**

- **Plans**
  - Prepare a semester work proposal that involves writing one or more paper, data collection and code development – update it as tasks get more clear
  - 4 OKRs for work objectives and measurable outcomes
- **Progress**
  - Maintain a blog document that has weekly updates of "Work done", "To-do for the Week"
    - Adviser could provide updates to be added to that doc with notes every week after 1-1 meetings
  - Keep in the folder - experiment plans, literature survey reports, Self Assessments
    - Use proper file names with meta-data and version update date
  - Keep a Powerpoint file that you update regularly with research progress updates, and that tells your research story
    - i.e., who is the hero, heroine, villain, story spin, fight scenes

# Google OKRs

## John Doerr's Deck

**OBJECTIVE:**
To Develop a Workable Model For Planning As Measured By:

**KEY RESULTS:**
1. Finishing the Presentation on time
2. Completing a sample set of **3** months Objectives and Key Results
3. Having management agree to institute a trial system for a **3** month period

OBJECTIVES & KEY RESULTS
2

## Sample Personal OKRs

- **Objective:** Improve Blogger's Reputation                    **.72**

  - **Key Results:**

    - Re-establish Blogger's leadership by speaking at 3 industry events          **1.0**

    - Coordinate Blogger's 10th birthday PR efforts          **.8**

    - ID and personally reach out to top xx Blogger users          **.8**

    - Fix DMCA process, eliminate music blog takedowns.          **.4**

    - Set up @blogger on Twitter, regularly participate in discussions re: Blogger product          **.6**

google ventures

# Research Work @ VIMAN Lab (2)

- **Literature**
  - Collect papers relevant to your research work and organize
  - Mark some ratings of the papers and keep critical feedback notes of important papers

- **Data**
  - Save data sets, old and new – organize them

- **Code**
  - Save code bases, old and new – organize them and keep documentation in code, in-context READMEs

- **Publication**
  - LateX files or Doc files of conference/journal papers in writing or published by you (i.e., your Deliverables)

# Self-Assessments

- **Fill out below questions in later part of semester (i.e., March, June or October end), give a grade (Good, Acceptable, Poor) and some \*\*brief description\*\* as justification to each item**

## 1. OVERALL SCORE:

(Honest assessment of your performance thus far, and one or two good reasons why your research work should be funded any further)

## 2. DEFINING A RESEARCH PROBLEM:

(Are you working on something that is keeping you awake at night?)

## 3. STUDY OF RELATED WORK:

(Do you have a 1-2 page document on this? Do you have 10-15 papers of generally related and 1 or 2 that are most related? If not, rate Poor)

# Self-Assessments (2)

## 4. EFFORT ON TEAM WORK:

(List your customers/collaborators within the team and outside. Have you interacted with the customers of your research and are they going to endorse your thesis work as needed and promising? If not, rate Poor)

## 5. PRELIMINARY RESULTS:

(List your deliverables - reports, demos, documents.)

## 6. INDIVIDUAL INITIATIVE:

(Have you taken initiative to get things done and made progress in research and pays-the-bill tasks? Provide 2 or 3 examples that exemplify your efforts. )

## 7. PROGRESS REPORTING DILIGENCE:

(Have you provided progress reports diligently through meetings and deliverables?)

# Research Work @ VIMAN Lab (3)

## 8. IMPROVED EXPERTISE AREAS:

(Where have you become a better person or expert - programming, systems, networking, technical writing/speaking?)

## 9. MAJOR MILESTONE DELIVERABLE DEADLINE:

(Are you going to have this completed satisfactorily? I will evaluate the outcome at this deadline, it is your responsibility to make it succeed with high-quality)

## 10. PAYS-THE-BILL DELIVERABLES:

(List them and show customers/collaborators have been engaged and will endorse your continued work)

# How do you know if your research is mature?
## "The Seven Steps Toward a Thesis"

- The idea
  - Is there a claim?
  - Is the claim clear?
  - Is the idea large or small?
  - Is the idea as large as it can be? Can you generalize it, or apply it elsewhere?
- Motivation, Use, or Application
  - Why should we care?
  - How can the claim be used? Are there other applications?
- Details of the Idea
  - What are the basic items/elements /representation units of the idea?
  - What are the rules or types of interrelationships between them?
  - How elaborated are these items and rules/relationships?
  - How much of the phenomena do they cover?

# How do you know if your research is mature? (2)
## "The Seven Steps Toward a Thesis"

- Data
  - Is there enough data in the study?
  - Is it representative? trustworthy? applicable?
- Discovery Methodology
  - Is the method of investigation clear?
  - Is it appropriate? Does it ignore phenomena that look relevant?
  - Is it well-reasoned? no biases or mistakes?
- History
  - Is prior work recognized? used?
- Proof
  - Is there an evaluation?
    - If so, is it adequate? Complete enough?
      - Does it speak to the claim?
      - Does it actually prove the claim?
    - If not, why not?
      - Is there a discussion of how one might try to test or prove the claim?
      - Can one make predictions and (easily) test them?

# Simplified, a research paper has…

- Abstract (4 sentences)
- Introduction (1 page)
- The problem (1 page)
- My idea (2 pages)
- The details (5 pages)
- Related work (1-2 pages)
- Conclusions and further work (0.5 pages)

# Further Reading

- How to do great research – Nick Feamster, Georgia Tech
  http://greatresearch.org/blog


- How to write a great research paper – Simon Jones, Microsoft Research
  http://research.microsoft.com/en-us/um/people/simonpj/papers/giving-a-talk/giving-a-talk.htm


- Write the paper first – Jason Eisner

  http://www.cs.jhu.edu/~jason/advice/write-the-paper-first.html