Better Privacy and Security via Secure Computation

Jonathan Katz

Security/privacy would be much easier…


…if there were someone
we could all TRUST
with our data

Better data mining -- using MORE data, while respecting users' PRIVACY


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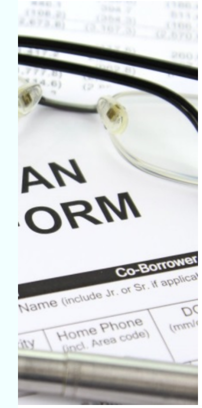

Office of Financial Research
Working Paper #0011
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Cryptography and the Economics of Supervisory Information: Balancing Transparency and Confidentiality

Mark Flood,[1] Jonathan Katz,[2] Stephen Ong,[3] and Adam Smith[4]

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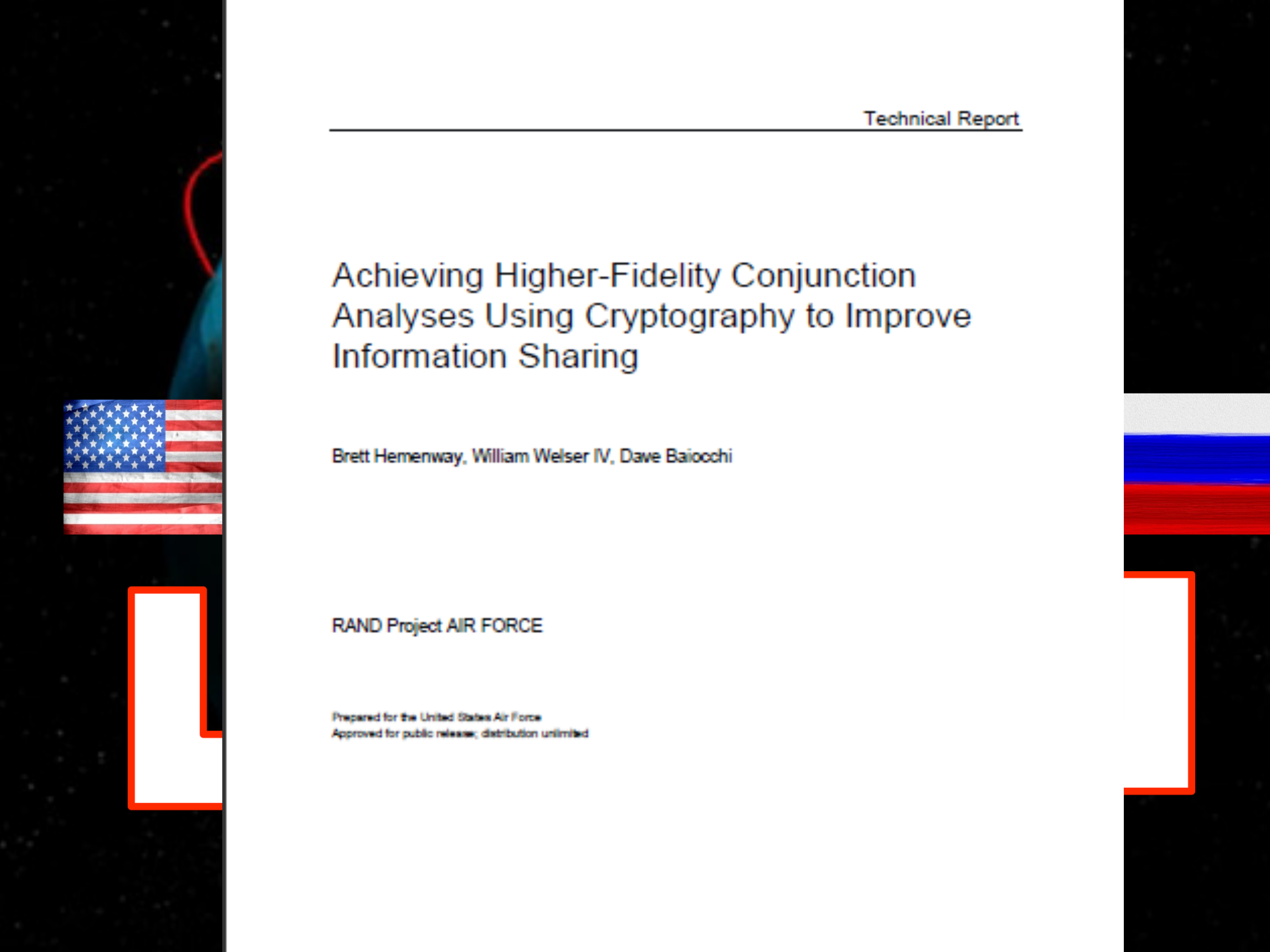
CONTROLLED information sharing



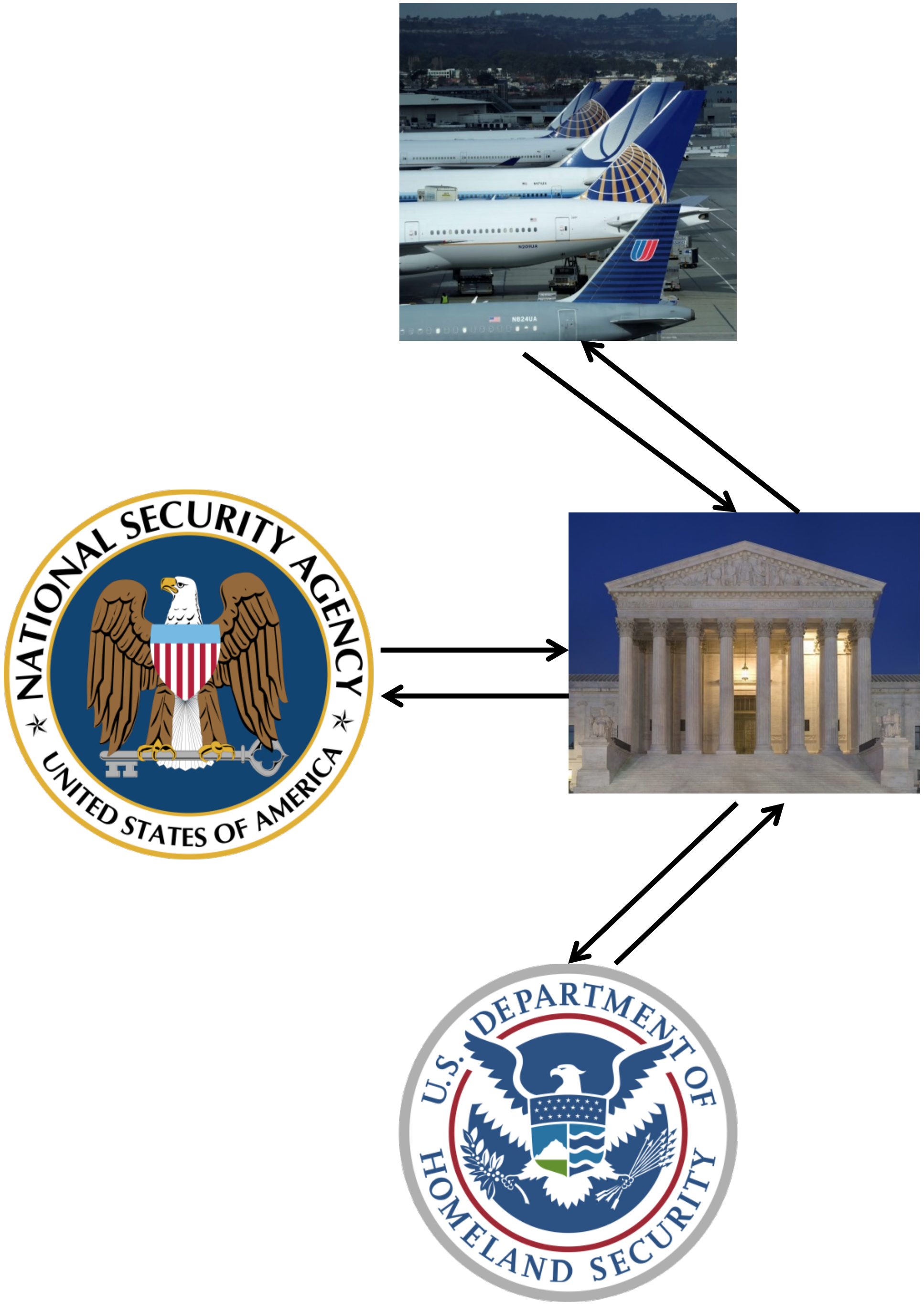
Technical Report

Achieving Higher-Fidelity Conjunction Analyses Using Cryptography to Improve Information Sharing

Brett Hemenway, William Welser IV, Dave Baiocchi

RAND Project AIR FORCE

Prepared for the United States Air Force
Approved for public release; distribution unlimited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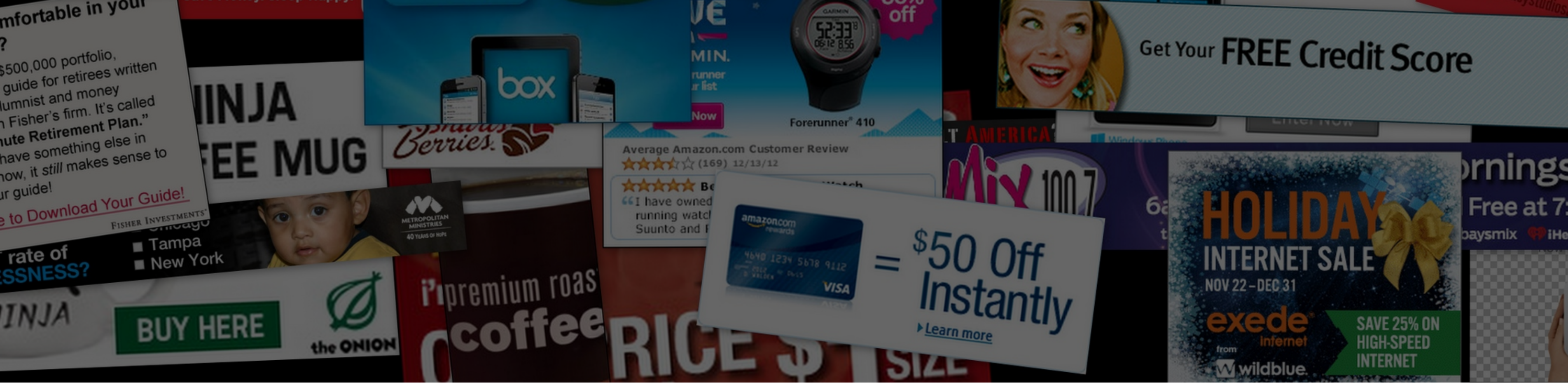
Better privacy/security
for EVERYONE



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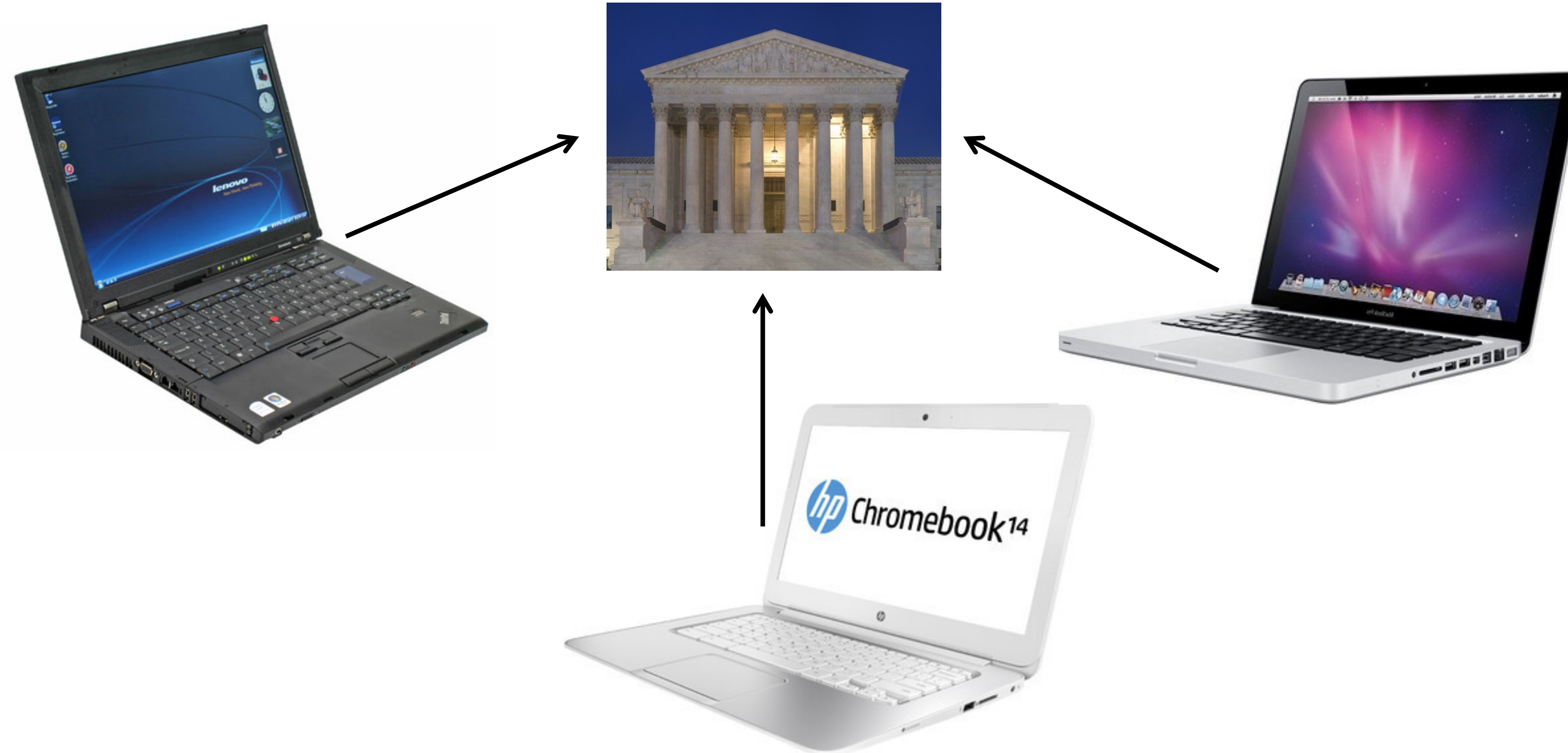
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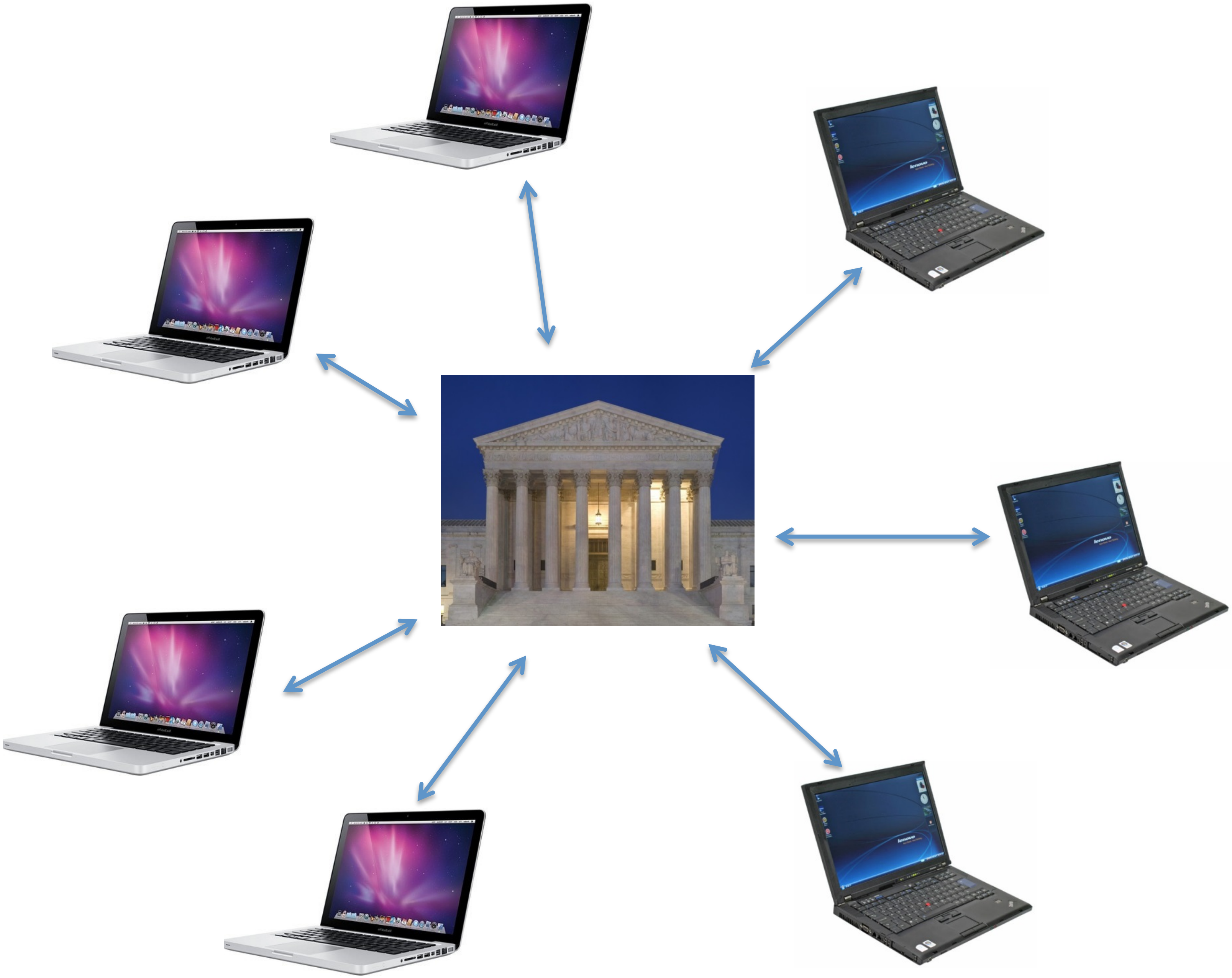
Would be nice if there were someone we could all TRUST with our data…

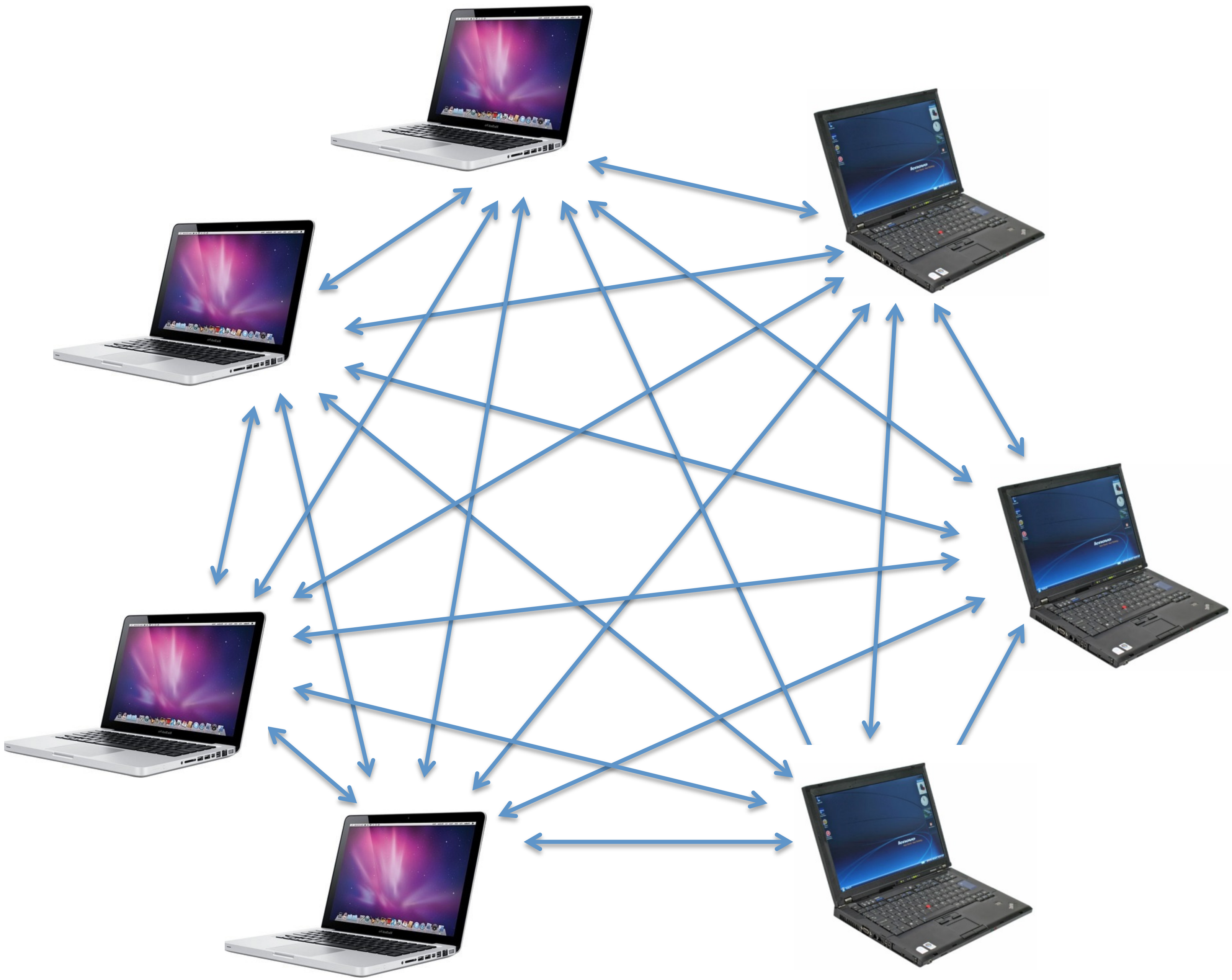
But there isn’t

- **Legal**/**regulatory** restrictions
- Not **economically viable** (cost + liability vs. value)
- **Central** point of failure/attack
- **Incompatible** trust frameworks

Would be nice if there were someone
we could all trust with data...

Would be even better if we could AVOID
the need for TRUST in the first place!





Secure computation ensures:

- **Confidentiality**
  - No party's input is revealed
- **Integrity**
  - Correct output is computed
- **Availability**
  - All parties obtain the output
- **Input independence**
  - Each party's input is *independent* of the others'

Caveats

Assumptions/caveats

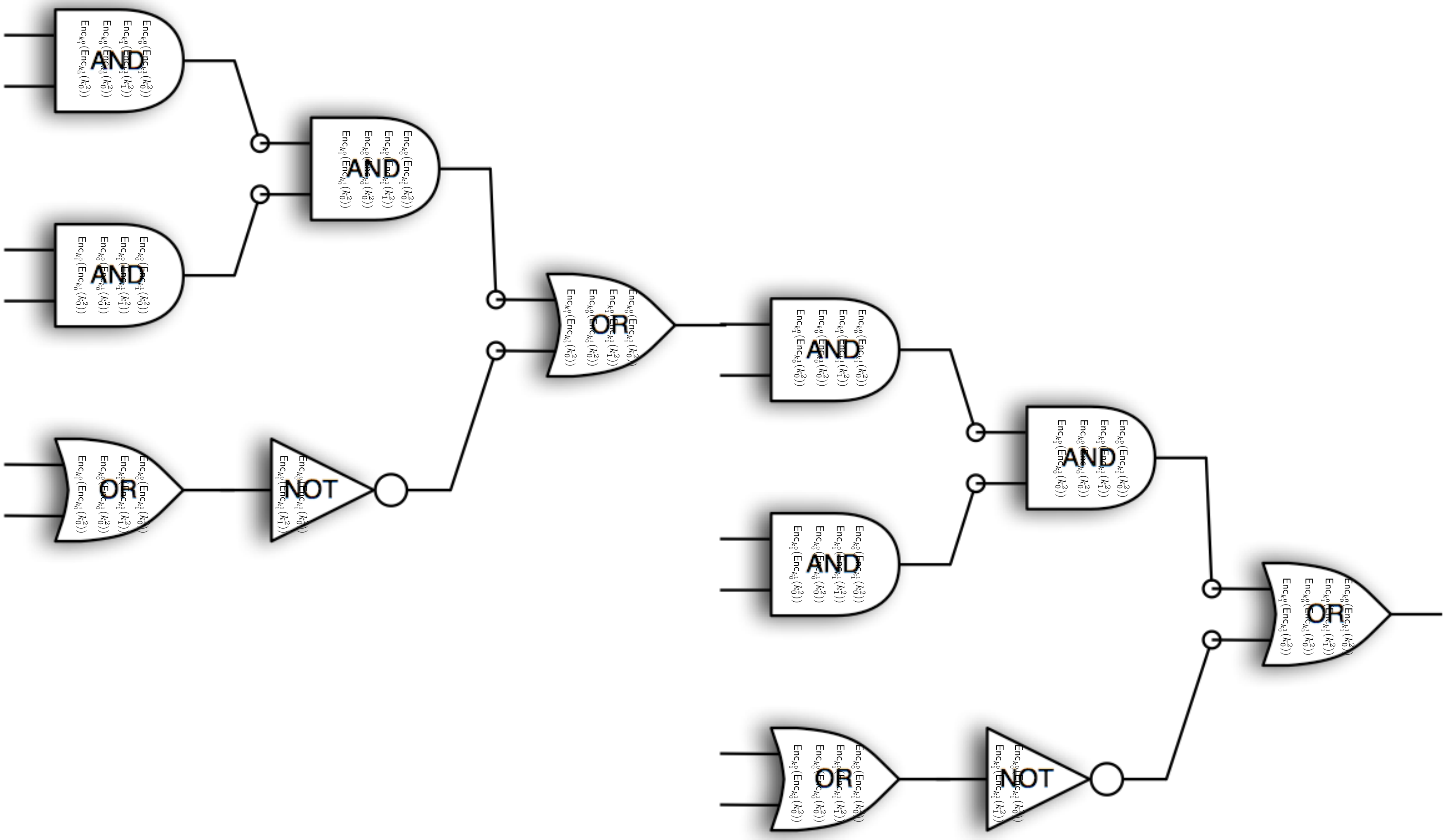
- **Number** of malicious parties (sometimes)
- **Actions** of malicious parties (sometimes)
- **Cryptographic** hardness (sometimes)
- **Weaker** guarantees (sometimes)

Secure computation of **any** function, with security against **arbitrary** behavior of **any number** of parties, is possible

Two-party setting

- Start with a boolean circuit for *f*
- P_1 sends a "***garbled circuit***" for *f* to P_2 along with keys for its own input
- P_2 obtains the keys for *its* input using ***oblivious transfer***
- P_2 evaluates the garbled circuit

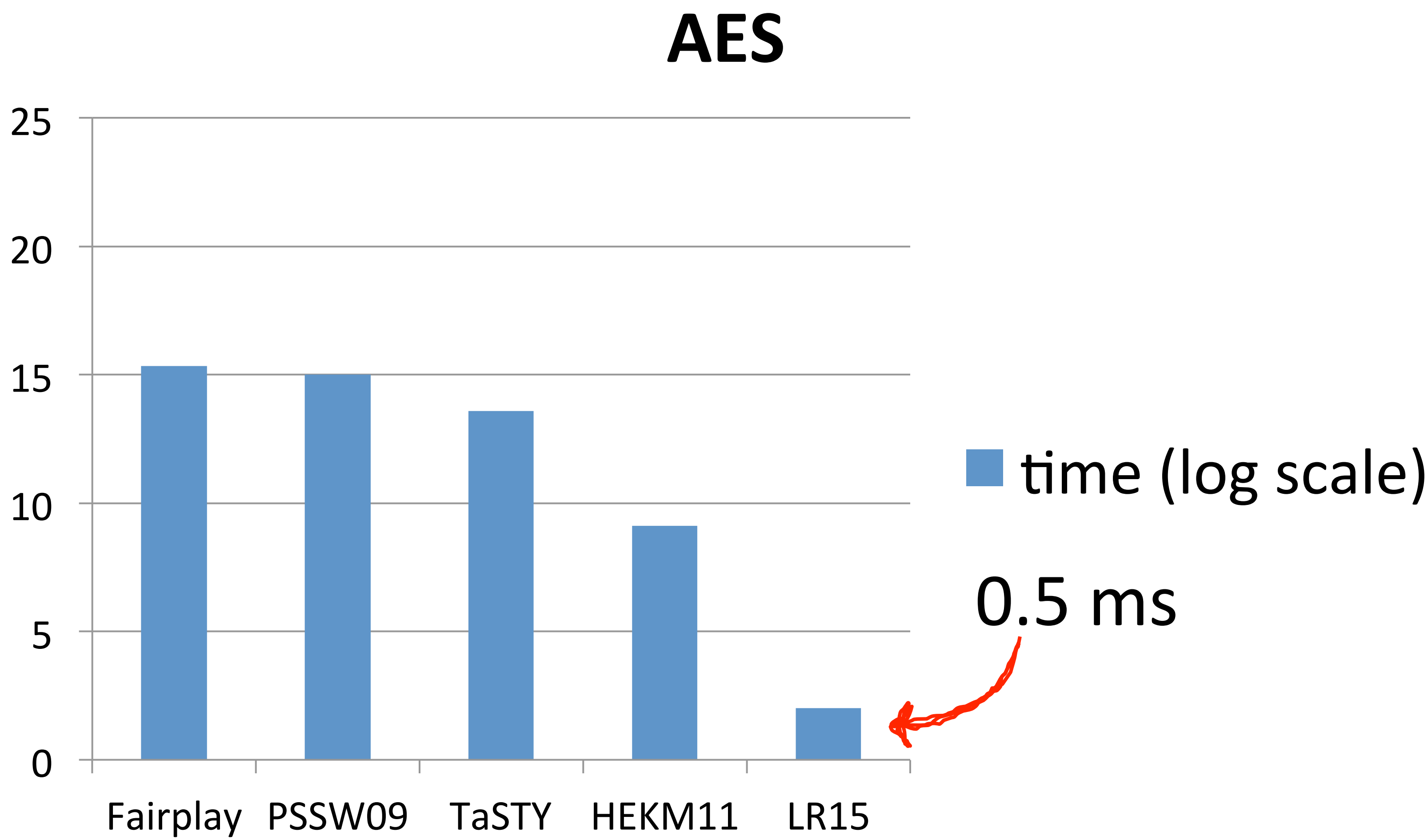
This gives semi-honest security only!



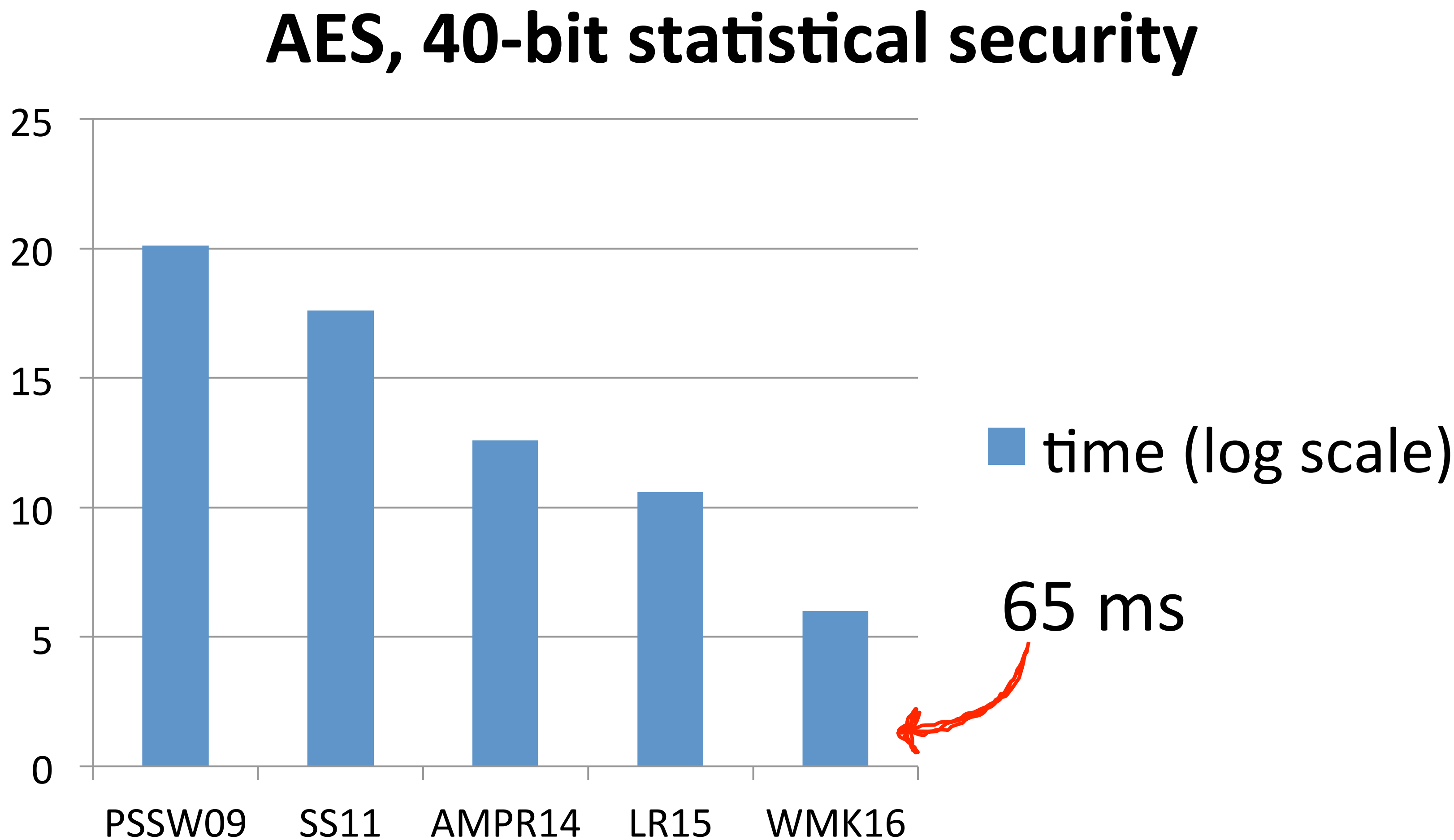
General feeling (~2000):

Hopelessly impractical

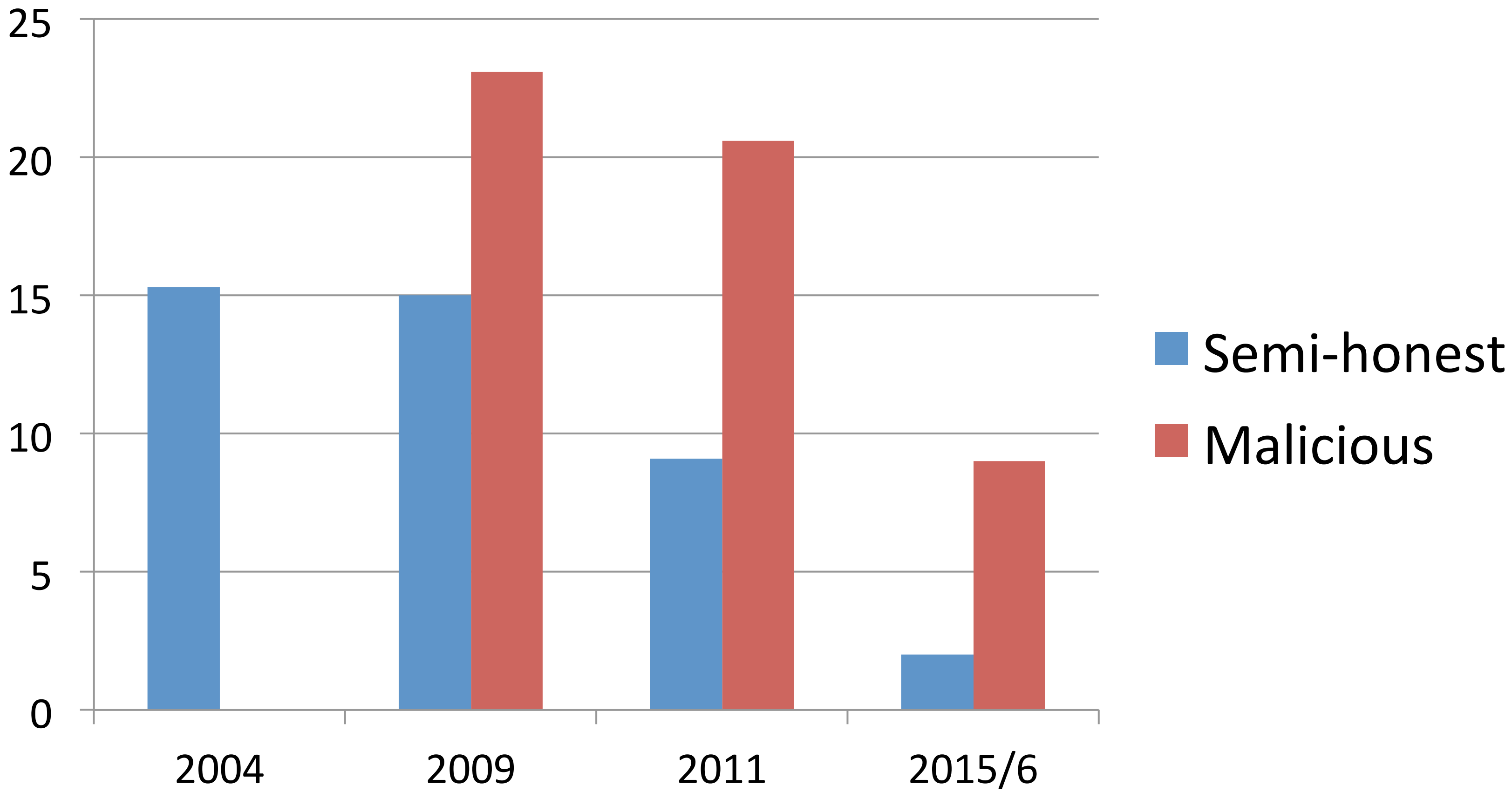
Efficiency (semi-honest)



Efficiency (malicious)



Efficiency



Real-world interest

- **Partisia (3-party)**
  - Danish sugar-beet auction (2008-present(?))
  - Wireless-spectrum auctions
- **Sharemind (3-party)**
  - Statistical analysis of financial data
- **Sepior, Dyadic (2-party)**
  - AES
- IARPA SPAR, DARPA PROCEED/Brandeis

Research questions

- “Cryptographic”
  - Multi-party setting
    - Protocols, “real-world” issues
  - Post-quantum security
  - Alternate models of computation
  - Composability
  - What functions are “safe” to compute?

Research questions

- "Non-cryptographic"
  - Usability
  - PL/compiler support
  - Formal verification of protocols, implementations

Real-world questions

- Will secure computation be of **niche** interest, or will it be more **widespread**?
- What is the **business model**?
- What **security requirements** suffice?
- What are the right **cost metrics**?
- What is the **barrier** to more widespread use of secure computation?

Real-world questions

- Will there be **multiple** applications of secure computation, or just a **few**?
  - Should we focus on **generic** systems, or optimize for specific “killer applications”?
  - What are the “killer applications”?
- Who will be writing code?
  - Where should we focus our attention when writing **compilers**?

Conclusions

- **Tremendous advances** in past few years
- Greater **deployment** in the near future(?)

Acknowledgments

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- US ARL/UK MoD ("Secure Information Flows in Hybrid Coalition Networks")
- DARPA ("Toward Practical Cryptographic Protocols for Secure Information Sharing")

Thank you!

Papers and code available from

http://www.cs.umd.edu/~jkatz/papers.html