UNDERSTANDING THE HOW AND THE WHY: EXPLORING SECURE DEVELOPMENT PRACTICES THROUGH A COURSE COMPETITION

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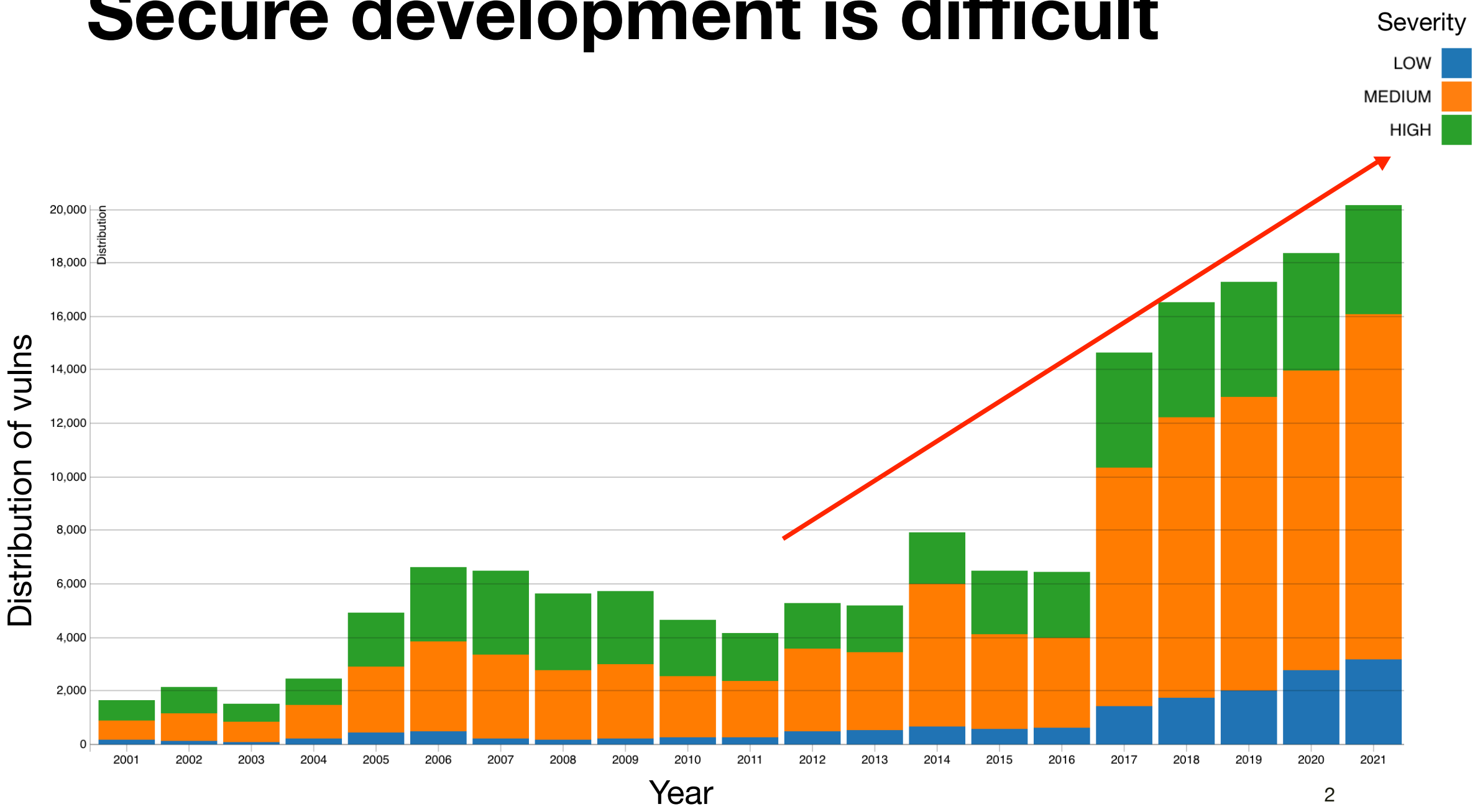
Secure development is difficult



Many solutions exist!

- Secure tools
- Secure training/ education
- Better integration of security

How do we help companies prioritize solutions?

We need to understand why and how different types of vulnerabilities get introduced, found, and fixed?

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Prior work

- Analyzed code submitted to BIBIFI

Build it, Break it, Fix it (BIBIFI)

Secure programming competition:

- **Build-it**
  - Build to a secure spec with open choices
  - Earn points for performance and functionality
- **Break-it**
  - Other teams' code made available
  - Submit exploits against other teams
- **Fix-it**
  - Update their code to fix submitted vulnerabilities

[Ruef et al., 2016]

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  - 94 projects
- Building in-depth taxonomy of vulnerabilities
- Uncovering characteristics of vulnerabilities
- Unable to uncover

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- Building in-depth taxonomy of vulnerabilities
- Uncovering characteristics of vulnerabilities
- Unable to uncover **how** and **why**

Research questions

- What type of vulnerabilities do developers introduce and why?
- What types of vulnerabilities are found during review and why?
- Why and how do developers fix different types of vulnerabilities?

Methods

- Used BIBIFI in 3 week long course
  - Spent approx. 1 week in each phase
- 14 teams composed of undergrads
  - Juniors/seniors
  - Participants had minimal security/development experience
- Participants were not expected to have prior security exp
  - Took core systems course
  - Had short lectures on security and threat modeling

Methods

- Collected fine-grained data
  - Design documents (multiple times)
  - Snapshots of code as they developed
  - Submitted exploits and fixes
  - Commit messages throughout build, break, fix

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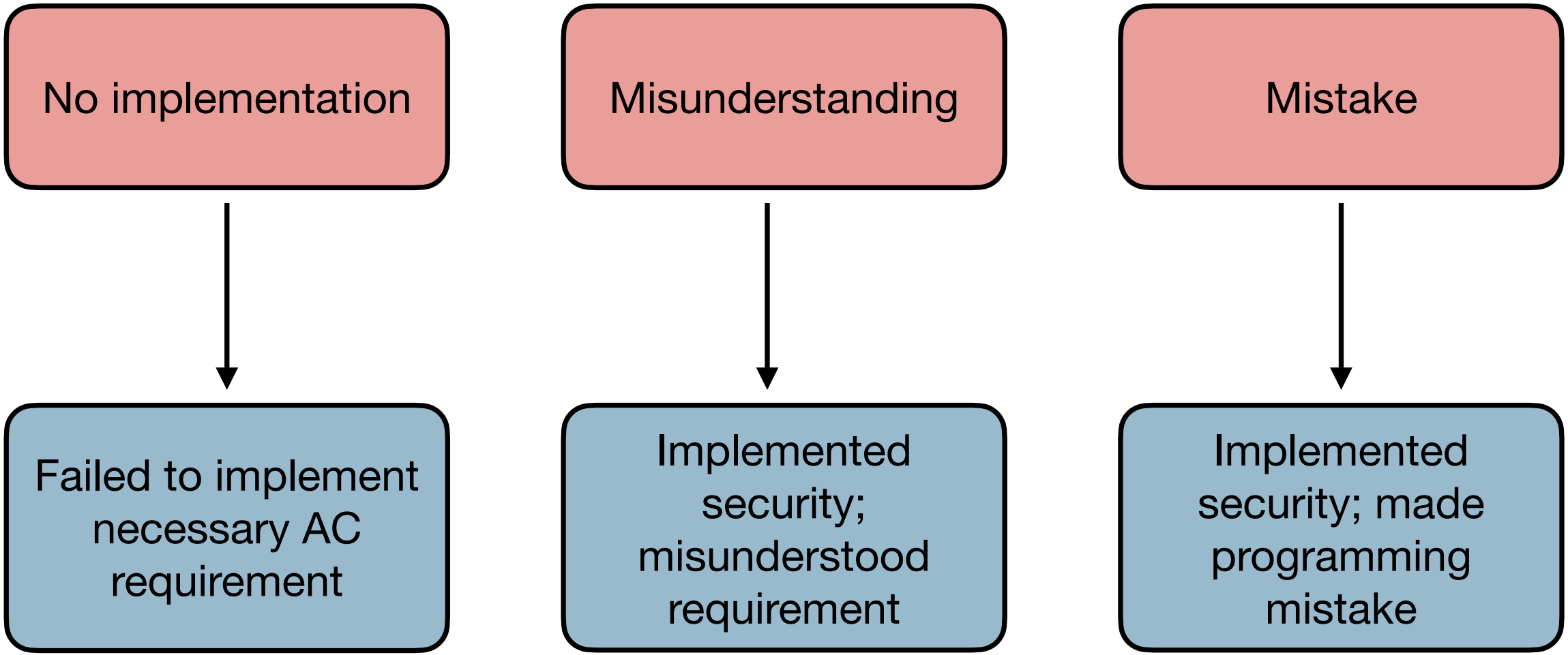
- Analyzed data using:
  - Manual code review for vulnerabilities
  - Qualitative coding

IoT smart home

- Runs user scripts
- All data protected by RBAC
  - Customizable by special users and data owner
  - Other users receive permissions

Overview of vulnerabilities



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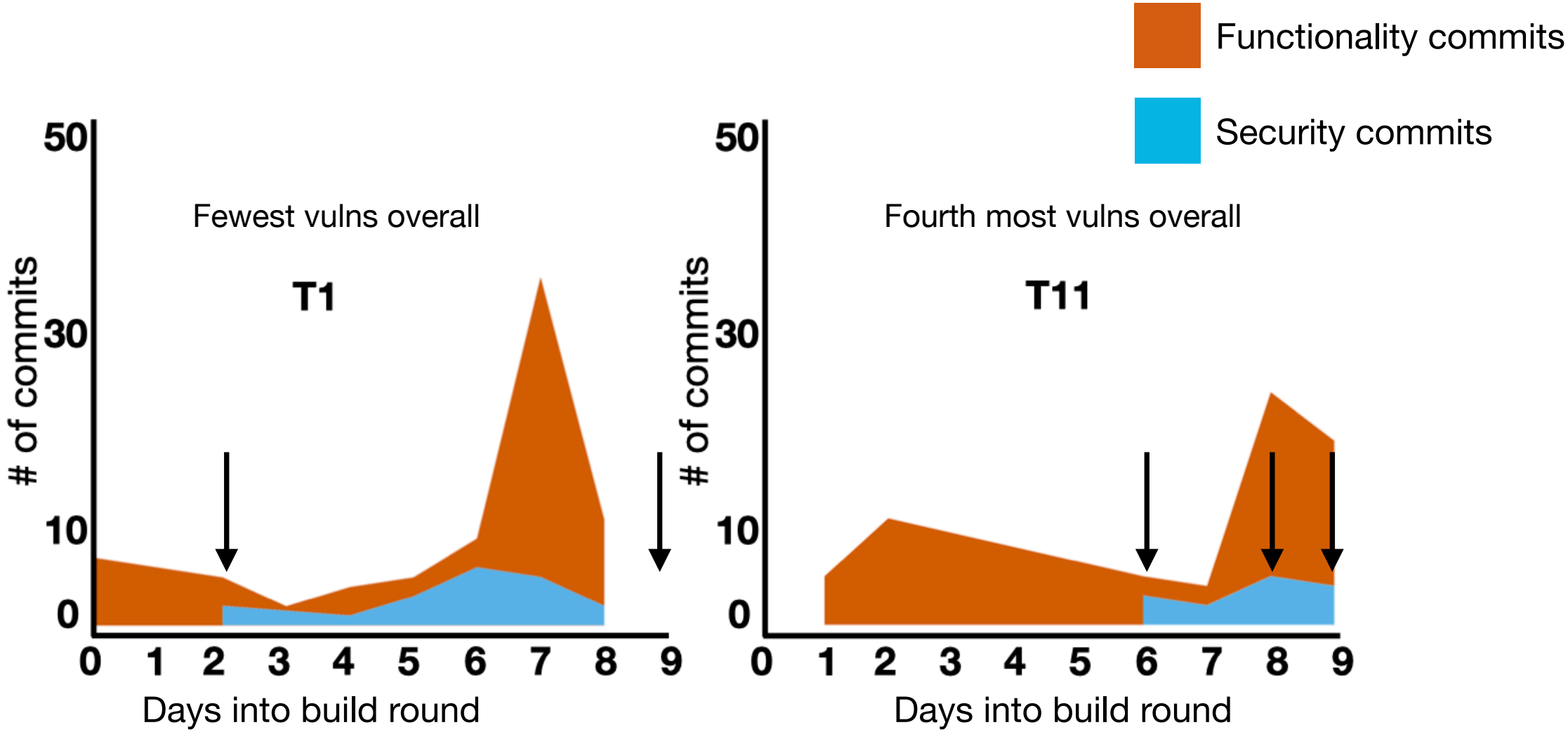
Impact of design on security

- Teams with detailed initial designs tended to introduce fewer vulnerabilities
  - Specifically No Implementation and Mistakes
- Teams with detailed initial designs tended to stick with them
  - Even if the initial design had a vulnerability
  - Especially prevalent with Misunderstandings

Impact of timeline on security

- Teams with fewest vulnerabilities tended to work on security throughout
- Teams that waited to work on security ran out of time
  - Resulting in many vulnerabilities

Impact of timeline on security



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Different vulnerabilities are discovered differently

- No Implementations found when looking broadly for related problem
  - Found one access control vulnerability while attempting to exploit another
- Mistakes were found through broad testing
  - Emulating the use of a fuzzer
- Misunderstandings required targeted testing
  - Many left unexploited

Research questions

- What type of vulnerabilities do developers introduce and why?
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Different vulnerabilities are fixed differently

- Half of No Implementations left unfixed at end of study
  - Rearchitecting whole system
- Misunderstandings were rarely fixed until exploited
  - But were overwhelmingly fixed once exploited

Implications

- Vulnerabilities differ in more than content
  - No “one size fits all” solution
- Importance of best practices
  - Incremental development
  - Detailed design
- Including security experts at beginning of development cycle

Questions:
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I am on the job market this year!