TODD AUSTIN

PROFESSOR, UNIVERSITY OF MICHIGAN
CEO, AGITA LABS, INC.

DISTRIBUTION STATEMENT A. Approved for public release

MORPHEUS: ADAPTIVE DEFENSES FOR TOMORROW’S SECURE SYSTEMS

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SECURITY: THE BIG UNSOLVED CHALLENGE

- What we do well:
  - Finding and fixing vulnerabilities
  - Deploying system protections that stop well-known attacks

Valgrind

Synopsys' Coverity Tools

ARM's TrustZone

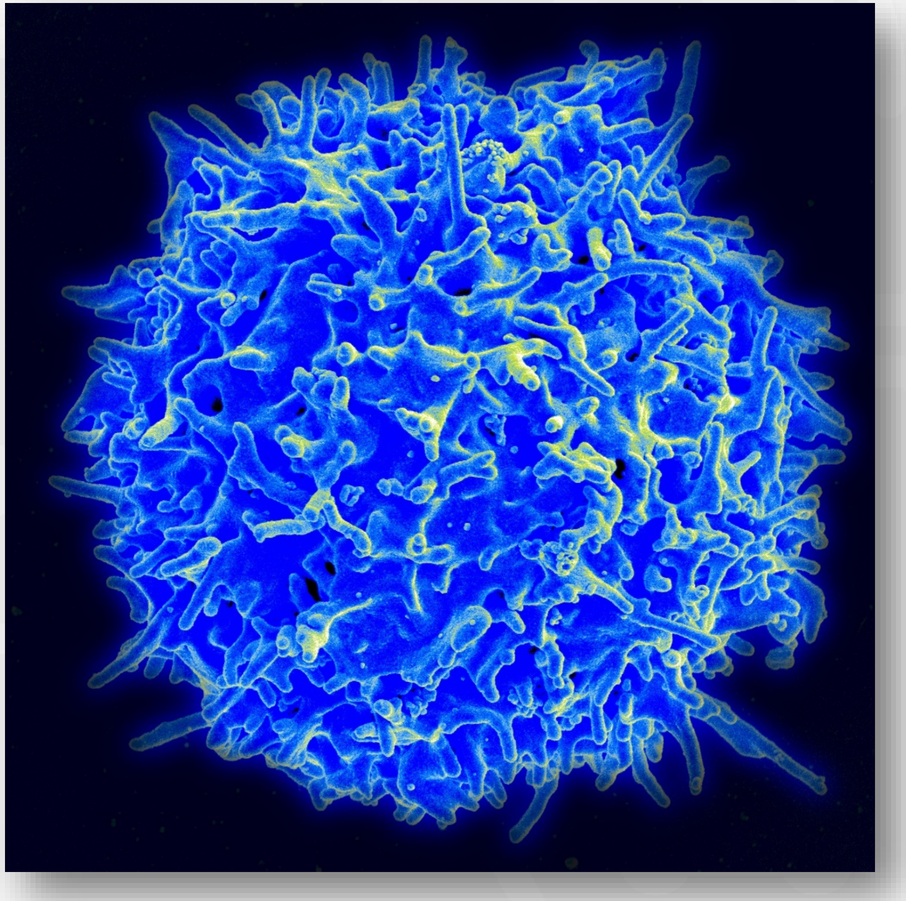
Intel's Control-Flow Enforcement

- Where we fail: ***identifying and stopping emergent attacks***

WHAT IF A SECURE SYSTEM COULD...

1. Respond lightning-fast against common attacks
2. Self-adapt quickly to unknown emerging threats
3. Learn and prioritize the most successful defense strategies
4. Utilize a self-protecting distributed implementation

T-Cell Adaptive Immunity



HUMAN ADAPTIVE IMMUNITY PRIMER

- T-cells receptors discern ***normal*** cells from ***malicious*** cells, via genetic markers

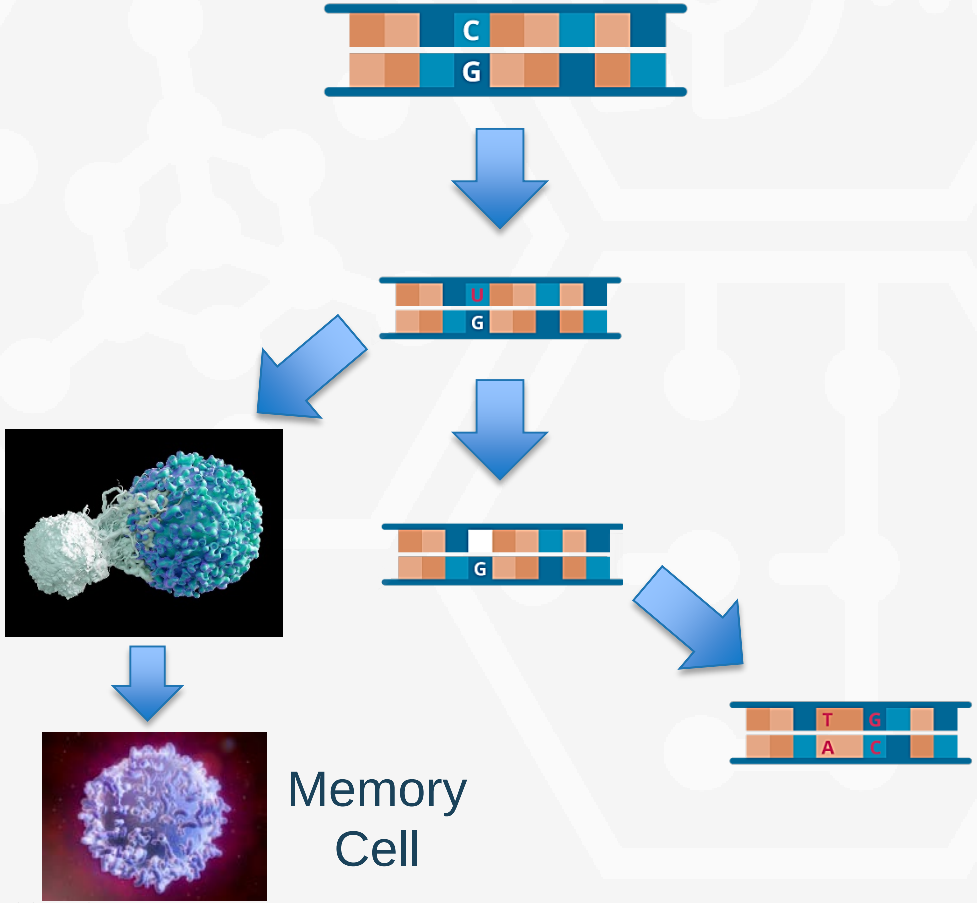
- To stop an unknown disease, T-cells undergo hypermutation that ***randomizes*** T-cell defense capabilities

- Boosted T-cell diversity will likely ***stop the pathogen attack***

- ***Immunological memory records successful T-cell variants*** to speed future recoveries

10^7 T-cell variants

10^{15} possible diseases



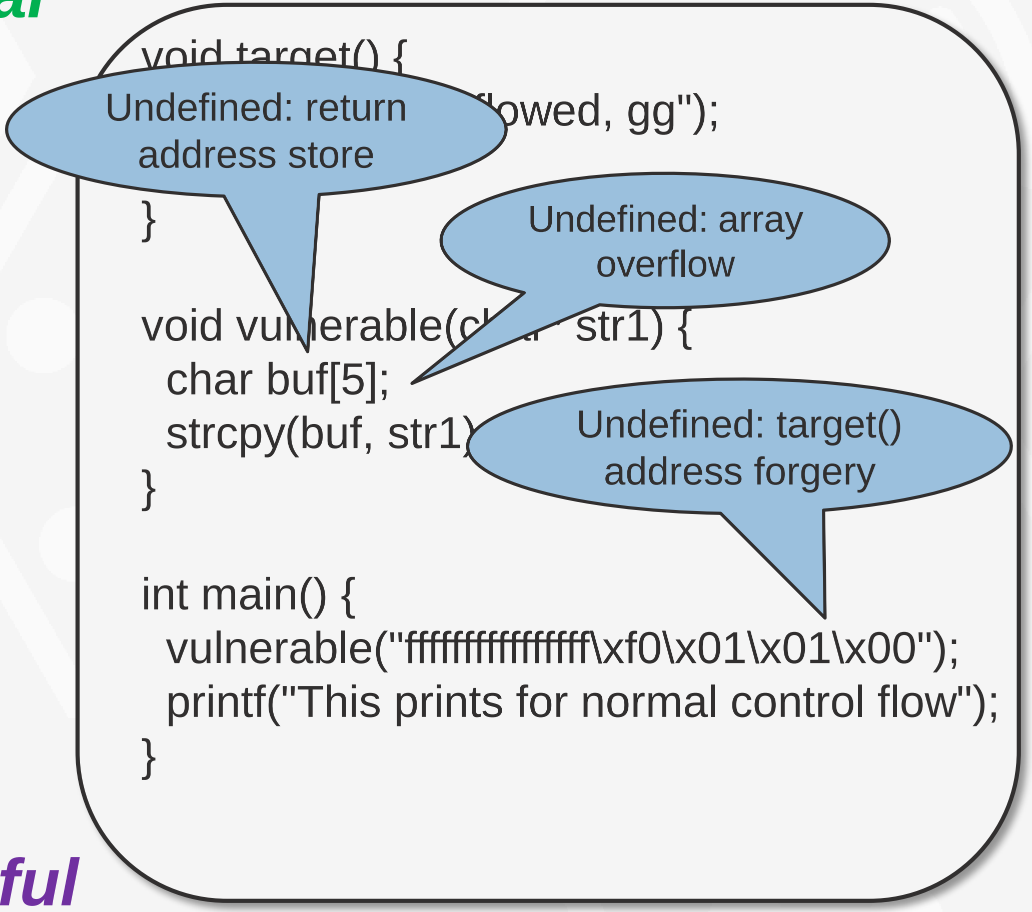
MORPHEUS MIMICS ADAPTIVE IMMUNITY

- Morpheus attack detectors discern ***normal*** code from ***malicious*** code, via undefined semantics

- To stop an unknown attack, Morpheus ***randomizes*** a system’s undefined semantics, a process called “churn”

- Churning undefined semantics ***stops security attacks***

- ***Learning mechanisms record successful defenses*** and stop future attacks quicker

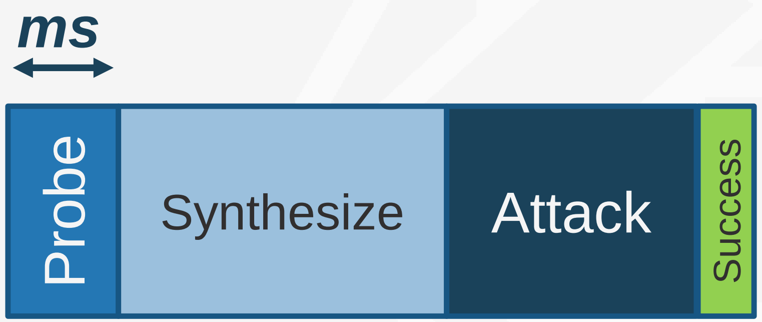


```
void target() {
                    lowed, gg");

}

void vulnerable(char* str1) {
  char buf[5];
  strcpy(buf, str1)
}

int main() {
  vulnerable("ffffffffffffffff\xf0\x01\x01\x00");
  printf("This prints for normal control flow");
}
```

Undefined: return address store
Undefined: array overflow
Undefined: target() address forgery

MORPHEUS BREAKS EMERGENT ATTACKS

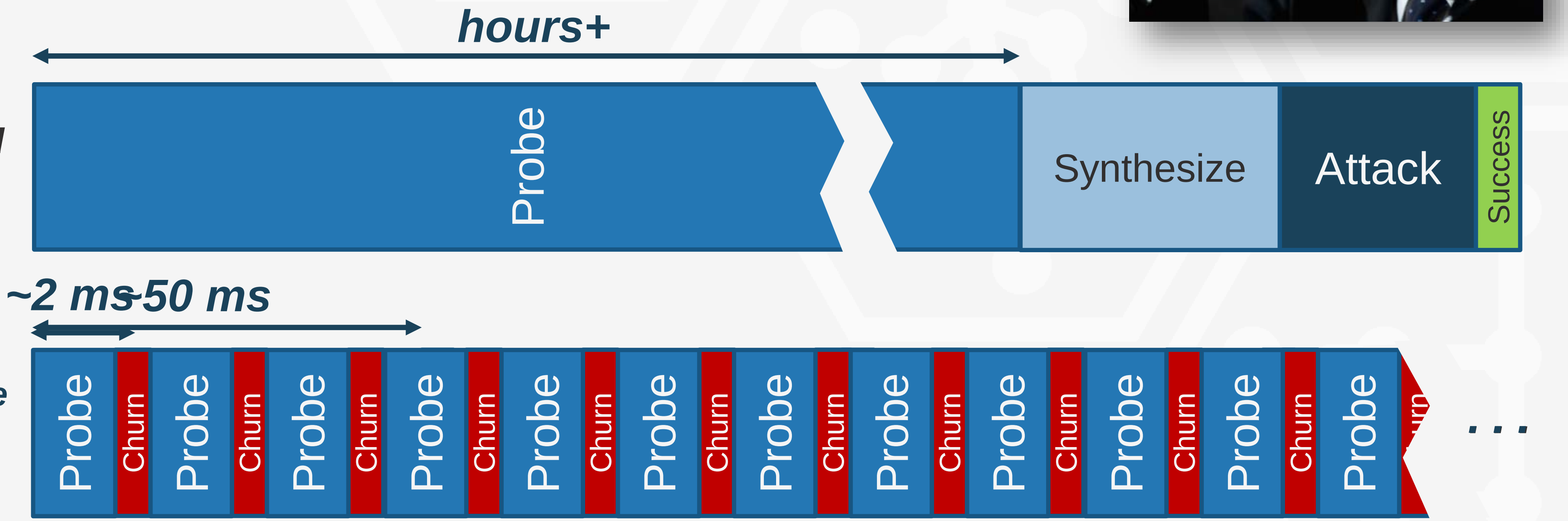
Conventional Attack



With Randomized Undefined Semantics

With Adaptive Churn and Memory

With Churn



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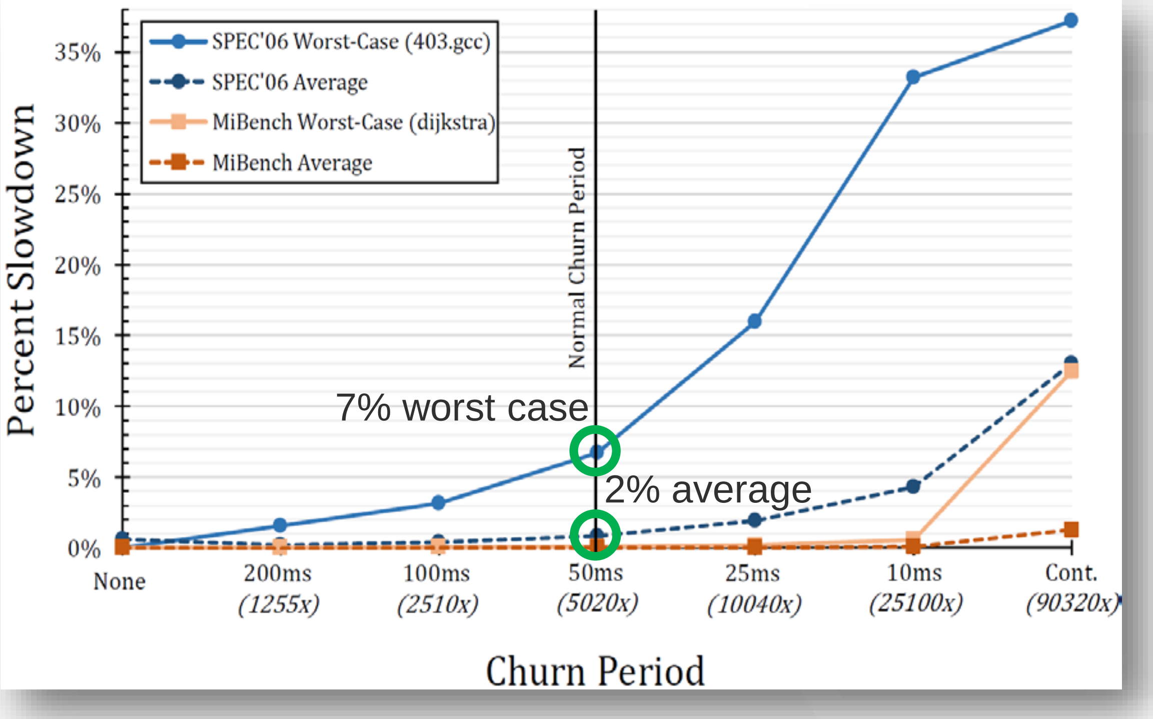
THE EARLY RESULTS LOOK PROMISING

Morpheus ***secure CPU*** developed in the DARPA SSITH Program with PM Linton Salmon. Team includes researchers from Michigan, Princeton and UT Austin

Early results:

- Performance cost: ***2% average slowdown*** with 504-bits of entropy and 50ms churn
- Power cost: ***2.5% power***
- Area cost: ***8% area*** increase
- Developer cost: ***No impact on normal applications***



COMMERCIALIZATION IS UNDERWAY

- ***Agita Labs*** is commercializing Morpheus
  - Integrated into the RISC-V ecosystem
  - Initially targeting ***server*** and ***IoT*** markets
  - Building ***FPGA & ASIC based secure CPUs***

- Two technology demos are in development
  - Secure ***voting machine hacking*** event at DEFCON
  - A second ***national-defense oriented demonstration*** is soon to start

- Visit http://www.agitalabs.com for more info

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