Automated Testing of Industrial Control Devices: The Delphi Database

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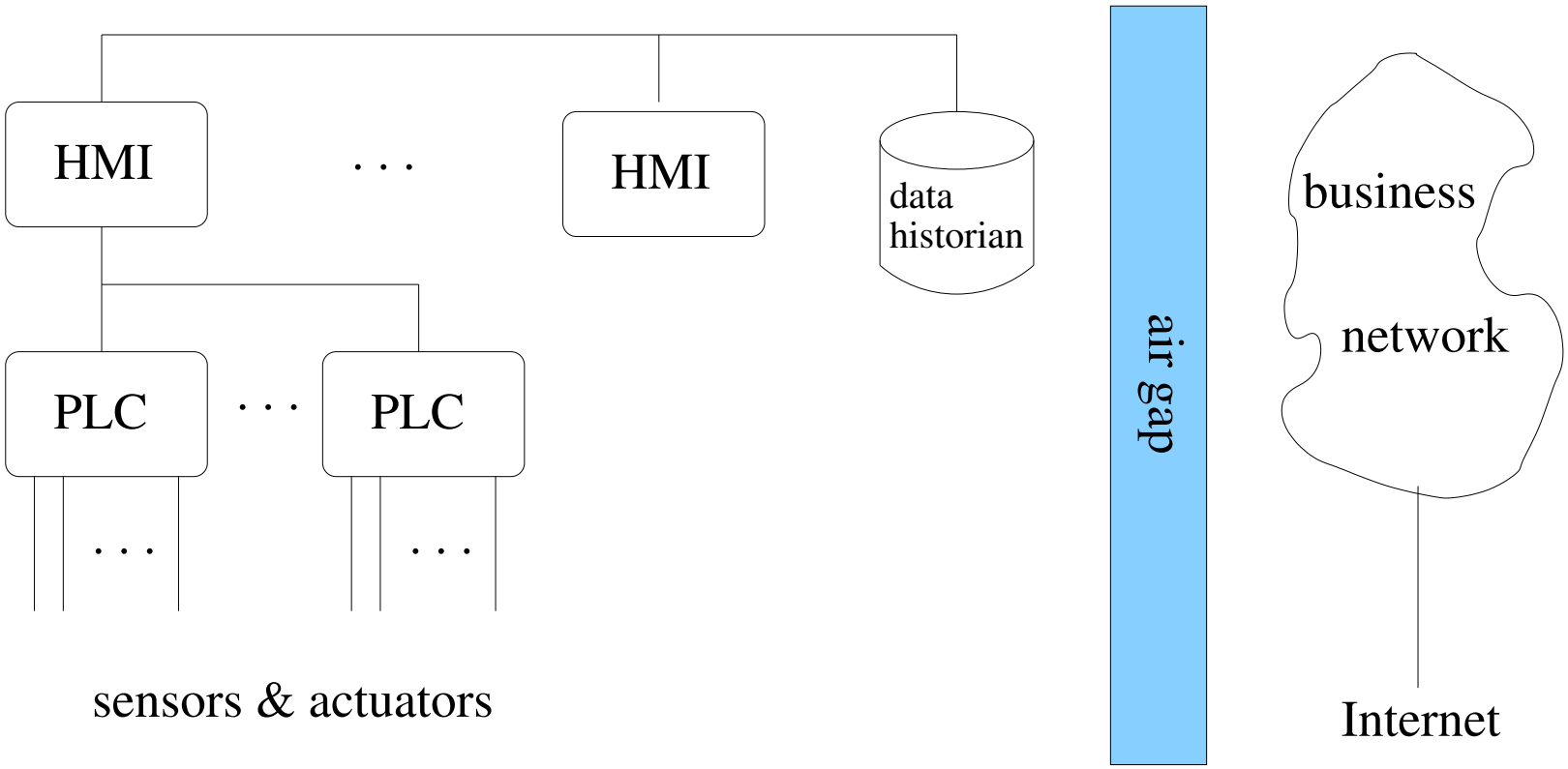
Networking in Industrial Control Systems



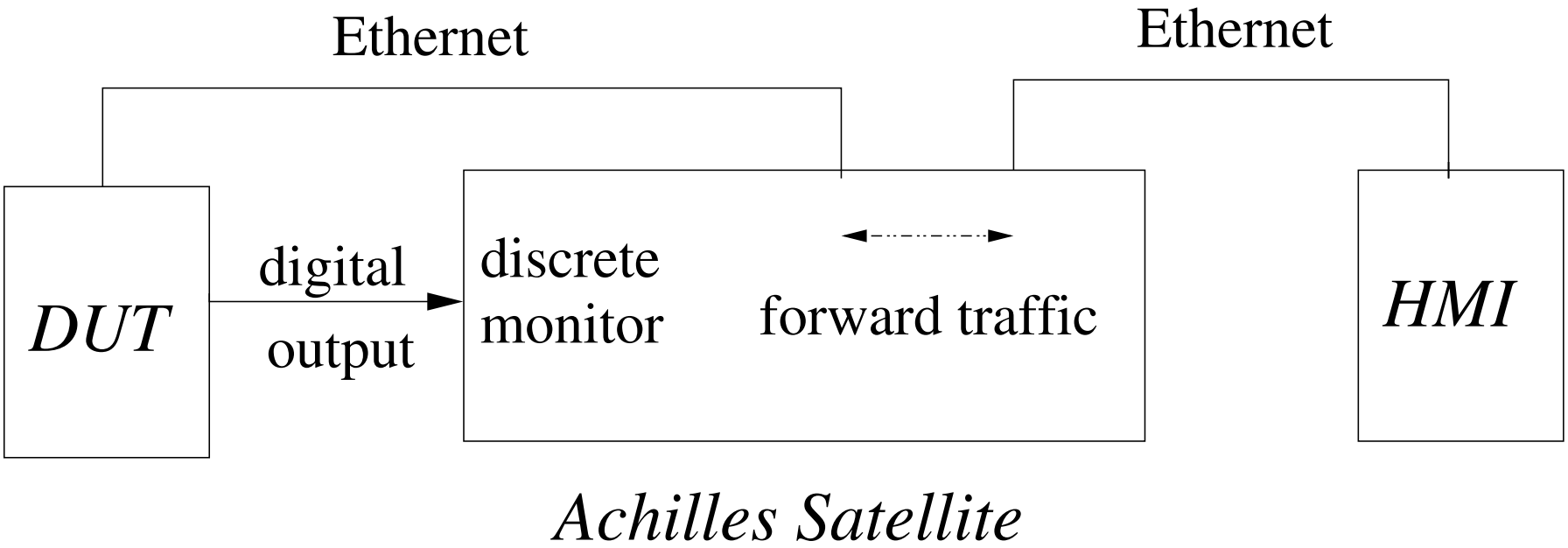
Talk Overview

- Networking: ICS versus IT
- Test harness
- Three test types
- Grammar-based test generation
- Database entries
- Prevention and mitigation strategies

The Internet versus the Factory Floor

	Internet	**Factory Floor**
Reliability	failures tolerated	failures intolerable
Risk impact	loss of data	loss of production, equipment, life
Performance	high throughput	low delay/jitter
Risk mgt.	recover by reboot	fault tolerance essential
Security	most sites insecure	tight physical/cybersecurity

Test Harness



Three Test Types

- Rate-based (≈ 10)
  - denial-of-service attacks
  - send packets at precisely controlled rates
- Known vulnerability (≈ 30)
  - send packets previously shown to exploit specific device vulnerabilities
- Grammar-based test generation (≈ 30)
  - specify tests with context-free grammar
  - focus on illegal packet fields and field combinations

Grammar-based Test Generation

- Grammar fragment

```
packet ::= ethernetHdr ethernetData;
ethernetHdr ::= srcAddr dstAddr protocol;
ethernetData ::= arpHdr | ipHdr ipData;
ipHdr ::= version ipHdrLen ToS ipTotalLen ...
tcpHdr ::= srcPort dstPort seq ack tcpHdrLen ...
```

- Bad lengths test: generate packets with correct header values, except that the lengths are inconsistent
  - **ipTotalLen** = 100 but transmit 117 bytes
  - illegal because the Ethernet header is 18 bytes

Database Contents

- Raw data
  1. Test data from 31 devices and approximately 10,000 tests
- Vulnerabilities: approximately 500 vulnerabilities stored
  1. Test case id
  2. CVSS score
  3. Monitors impacted
  4. Packet rate
  5. Packet size
  6. Recovery time
  7. Device type
  8. Relevant industries

Operator Mitigation Strategies

- Rate limit network traffic
- Block the TCP/IP LAND attack
- Prevent port scans
- Be wary of fragmented packets
- Block impossible packet header field combinations

Vendor Prevention Methods

- Drop unsolicited ARP replies
- Carefully manage memory/CPU utilization
- Assume the worst about network input
- Properly manage data buffers
- Rate-limit traffic

Conclusions

- *Problem*: changes to security policies and networking technologies have made ICS networks too vulnerable to cyber-attack.
- *One attack on this problem*:
  - a framework for testing a wide variety of devices thoroughly and at reasonable cost.
  - validated on significant set of devices
  - produced description of specific device vulnerabilities
  - supported recommendations for prevention and mitigation
- An opportunity for AST researchers:
  - improve the quality of the software in the "critical infrastructure"