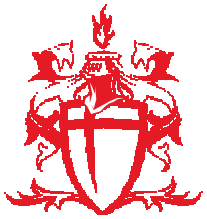

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LONDON

Diversity for Safety and Security in Embedded Systems : decisions given supply chain risks

Lorenzo Strigini
Centre for Software Reliability, City University London, U.K.

reporting work with Andrey Povyakalo, Ilir Gashi

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CSR Building confidence in a computerised world
www.csr.city.ac.uk

Background: the SESAMO project (2012-15)

Security and Safety Modelling

- *for embedded systems*
- *14 companies and 6 research institutes*
- *in Europe and the U.S.*

http://sesamo-project.eu/

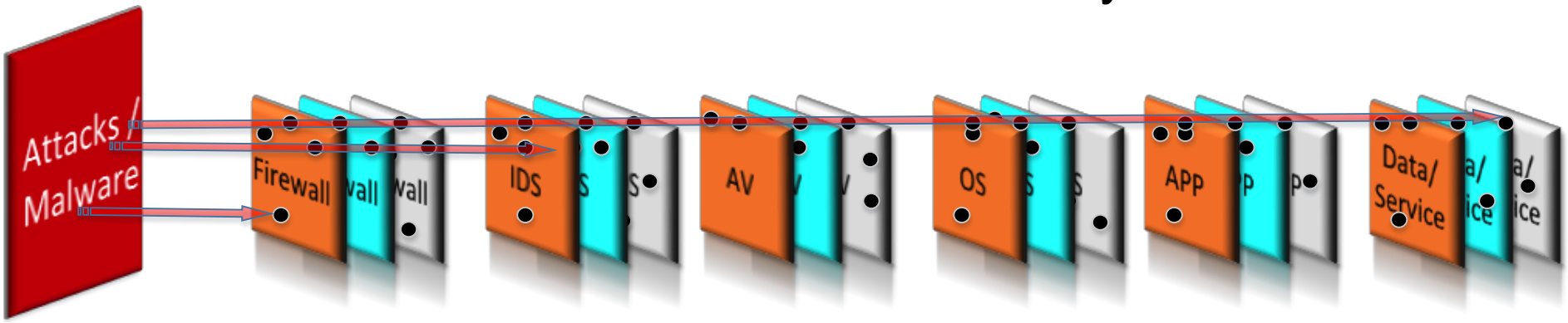
objectives include:

- joint reasoning about safety and security properties, their **conflicts and synergies**
- a model-based methodology and solutions for addressing safety and security within an integrated process, supported by an effective tool chain
- validation in use cases in multiple industrial domains (e.g. aerospace, energy management, automotive, ...)
  - also other CSR work here on
    + Impact of Cyber Attack in Critical Infrastructures
    + Safety-informed safety cases

Background: D3S project (2015-18)

Diversity and Defence in Depth for Security

- Security is a matter of diverse layers
- to which one can add intentional diversity

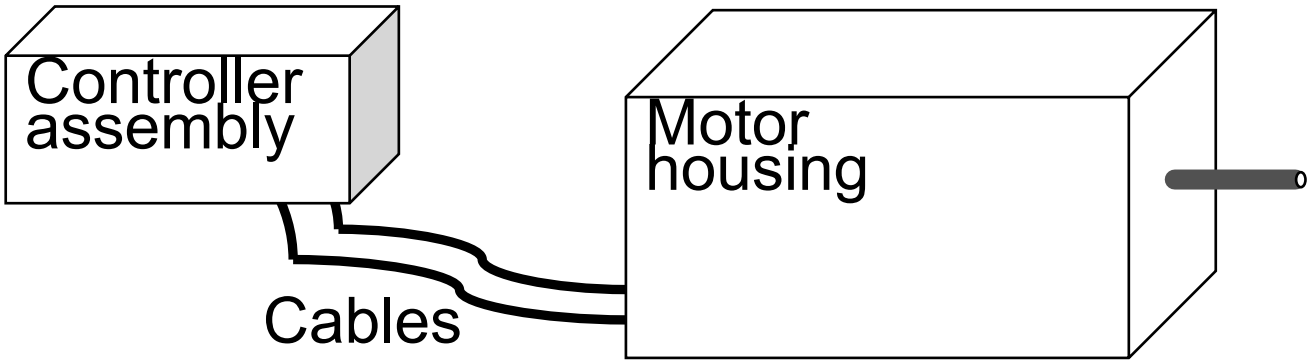


- ... to no end !?
- how do we decide how much is enough
  - or whether *this* architecture is better than *that* architecture?
  - in view of multiple requirements
- D3S directions
  - probabilistic modelling for insight
  - data collection to estimate joint effectiveness
  - studying how (how well) these measures support *prediction*

The example: industrial drive control

- inspired by aSeSaMo project "use case"
  http://sesamo-project.eu/content/industrial-drive

- electric motor under computer control
  - generic control unit; motor could be for any load...



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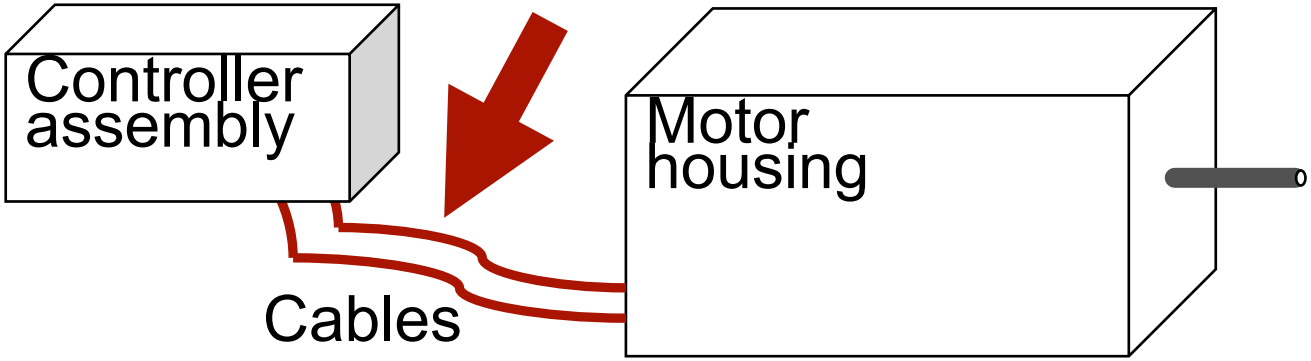
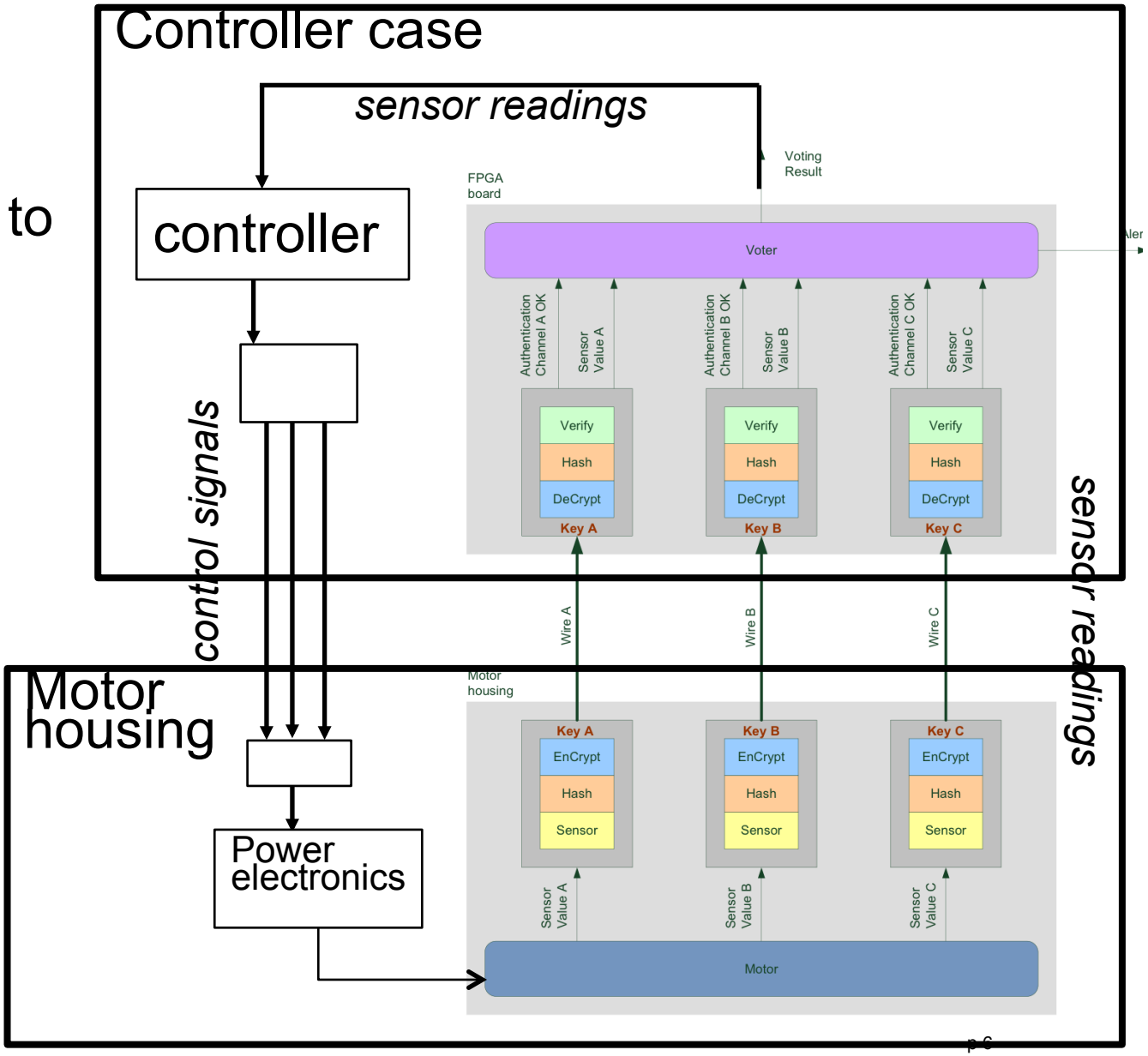


- attackers may want to perturb motor operation
  - through access to *communication*
- for both safety and security, communications are *replicated* and *encrypted* – **diversely***? how, and with what gain?*

Our example... Industrial drive control

- to analyse: communication between the two parts
- adversary trying to *intercept* / *inject* messages
- communication *triplicated* & *encrypted*
- encryption for both confidentiality & authentication (here we study simplest design: "authentic" if it decrypts to a legal message)



The questions, the uncertainties

- communication is **replicated** for reliability, safety
  - against accidental faults
- and **encrypted** for integrity and confidentiality:
- prevent attacker from
  - reading real signal
  - crafting and inserting forged ones
- good encryption on each channel guarantees all this
- ....or maybe not!

What about crypto "**implementation errors**" in hardware, software, operation, management?

use ***diversity***!

But..

- *how much* will it help? (is it worth doing?)
- how will helping *integrity* harm *confidentiality*?

Security concerns studied

cryptography "implementation" flaws:

- flaws that make *cryptanalysis* affordable
  with decent chance of success
  – search of reduced key space
    + over days or years
  – how helpful is it to use *diverse keys ?*
- shortcut to penetration through *supply-chain* flaw
  – intentional chip design flaw, insider selling keys, ..
  – how helpful is it to diversify vendors, designs, algorithms..?

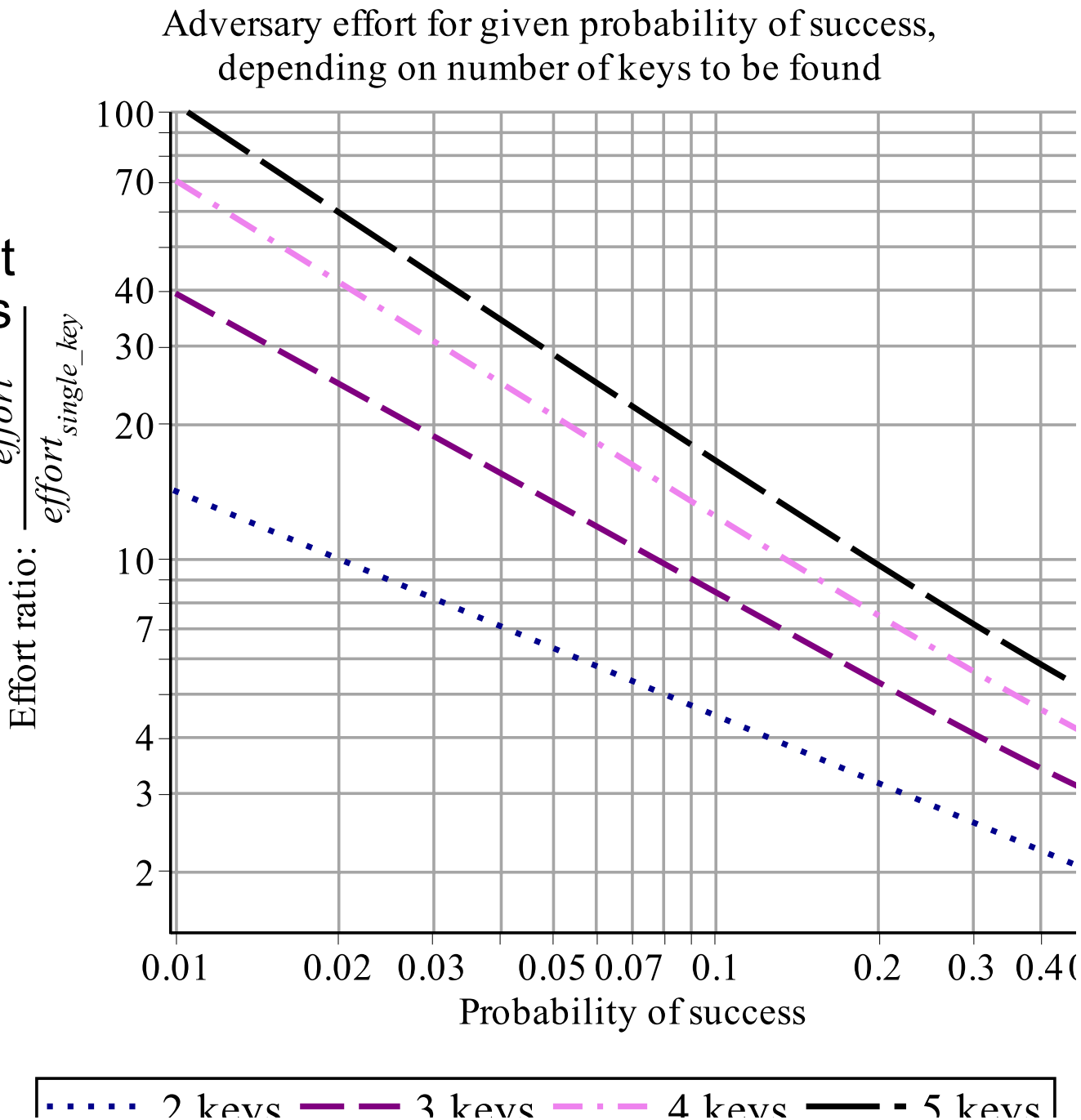
Adversary may want to

- highjack majority of control channels
  – to cause accident/loss
- spy on communication
  – to engineer better attacks
  – or to steal secrets

Example answers

"Affordable cryptanalysis" scenario

- *substantial* protection against *non*-ruinous flaws
- relevant for high-value targets
- if adversary is willing to attack for 5% chances of success.. diverse keys will cost 7 times the effort for same chances
- should he even try?



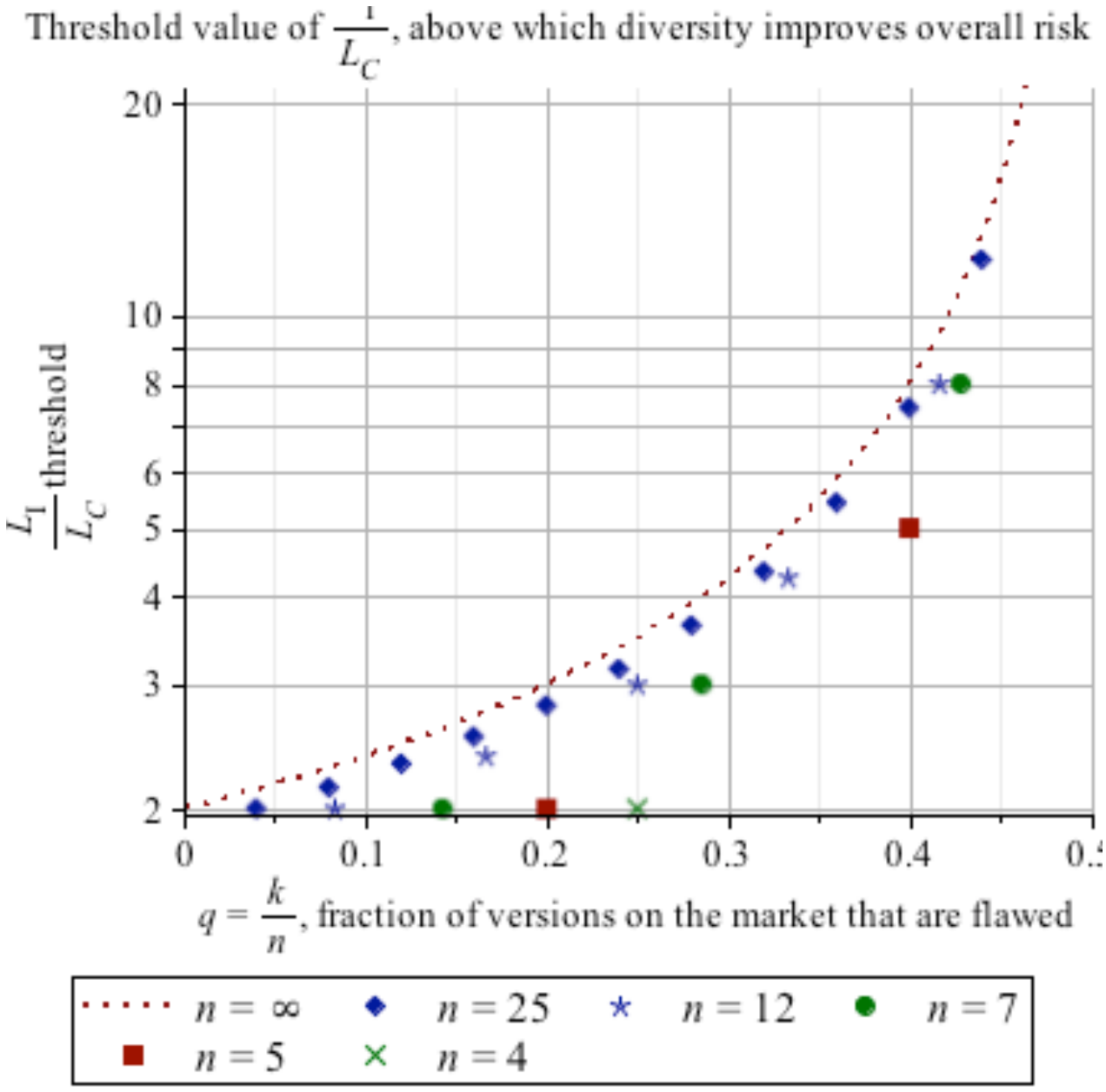
"Supply chain" flaws: when should we use diversity?

n implementations available,

for *k*, adversaries know holes

diversity buys *integrity at the cost of confidentiality*

use diversity if the *expected loss* from having an "integrity flaw" (2 flawed channels) exceeds this many times the expected loss from having a "confidentiality flaw" (1 flawed channel)



Some observations / conclusions

- useful insight from simple modelling
- simple, hence covering general classes of scenarios
  - attacks on safe shutdown ability of safety system
  - breaking into two user accounts
- results in paper at EDCC2016
- Extensions under way:
  - modelling more complex, realistic attack modes (the easy part)
  - dependencies between successes on two channels
    - causal and epistemic
  - guessing plausible model parameters from evidence