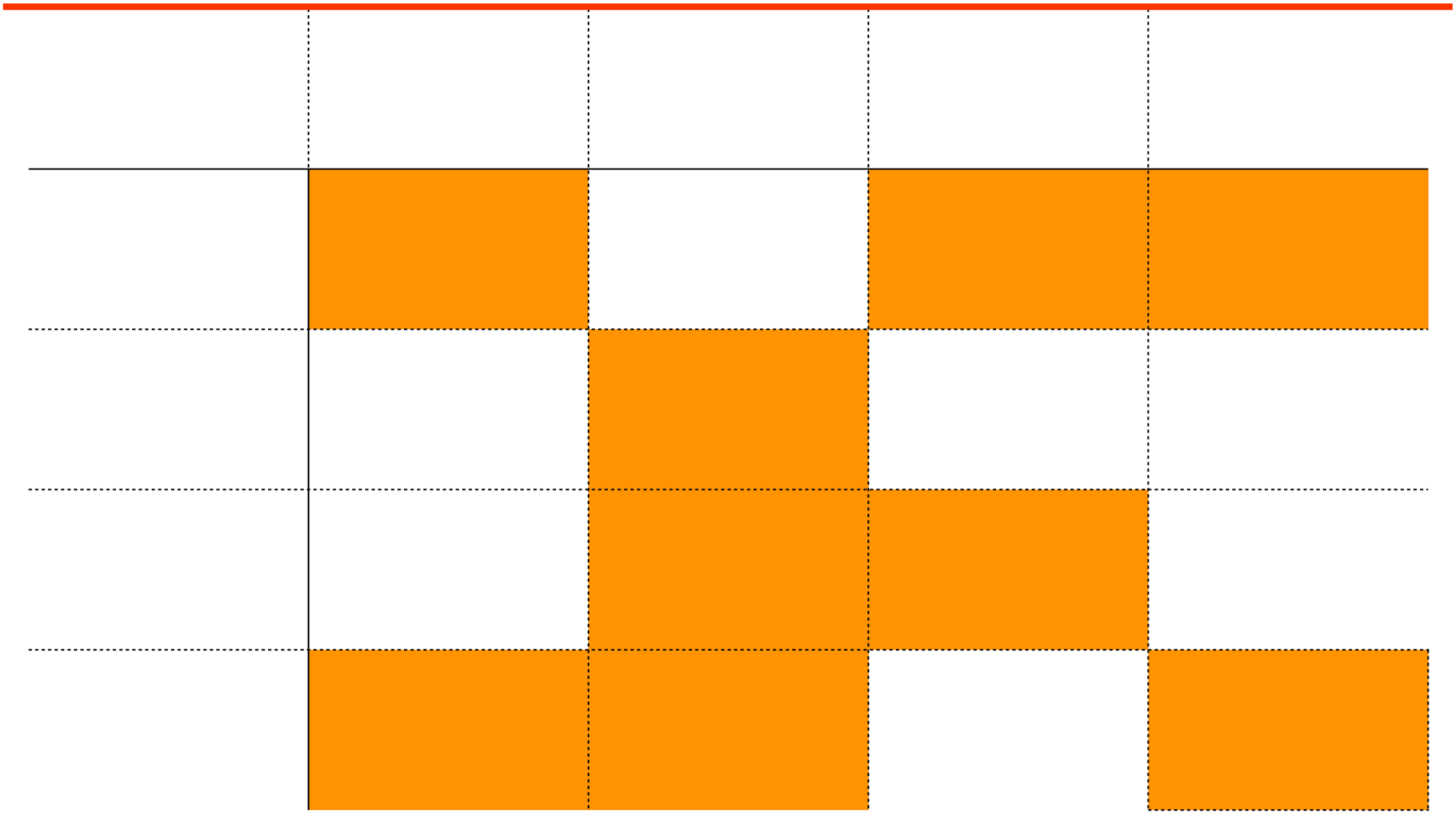
Verify what?

Navigating the Attack Surface

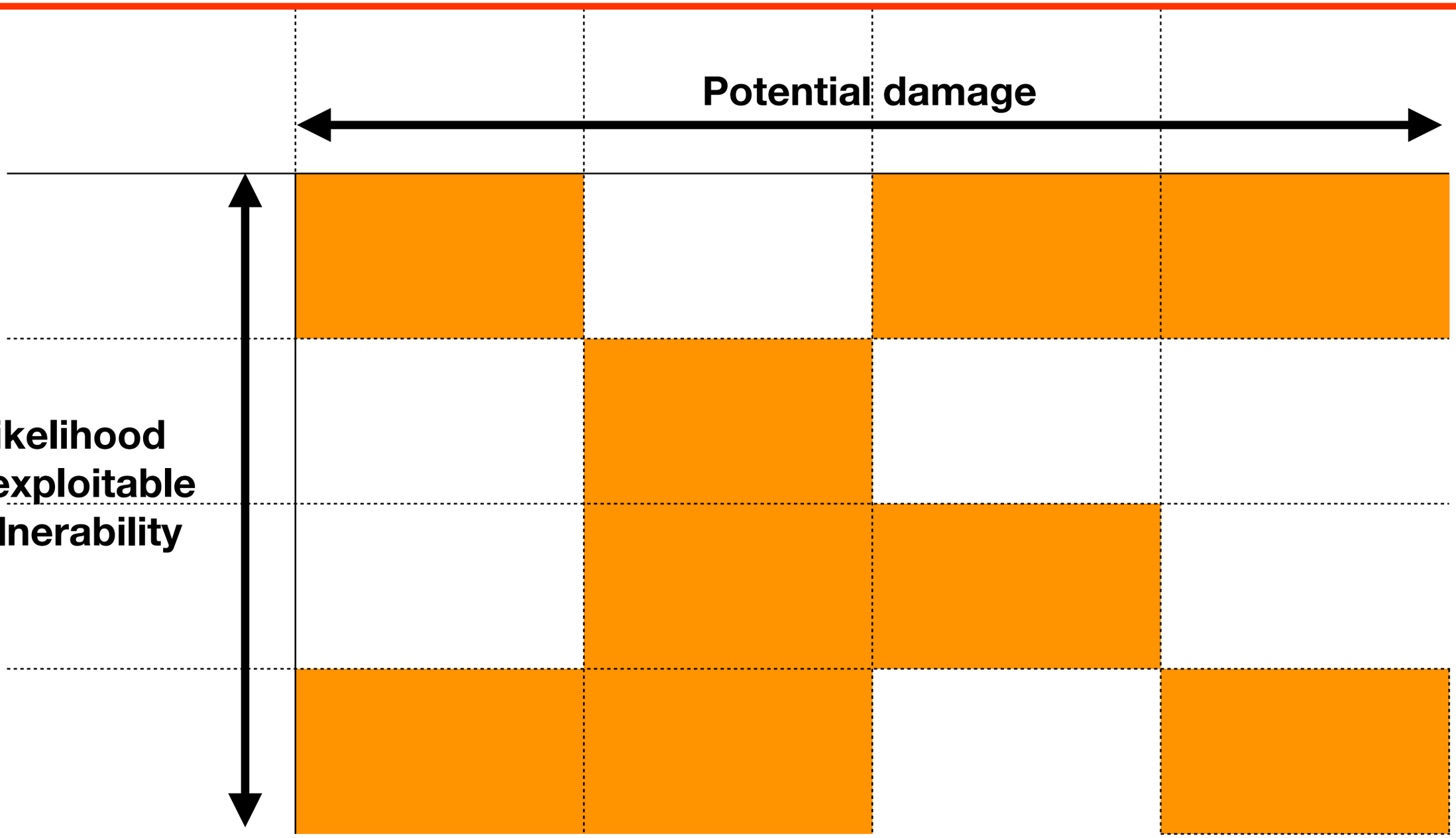
Mark S. Miller, Google

Formal Methods meets JavaScript
Imperial College, March 2018

Risk as Attack Surface



Expected Risk: $\int$ likelihood * damage



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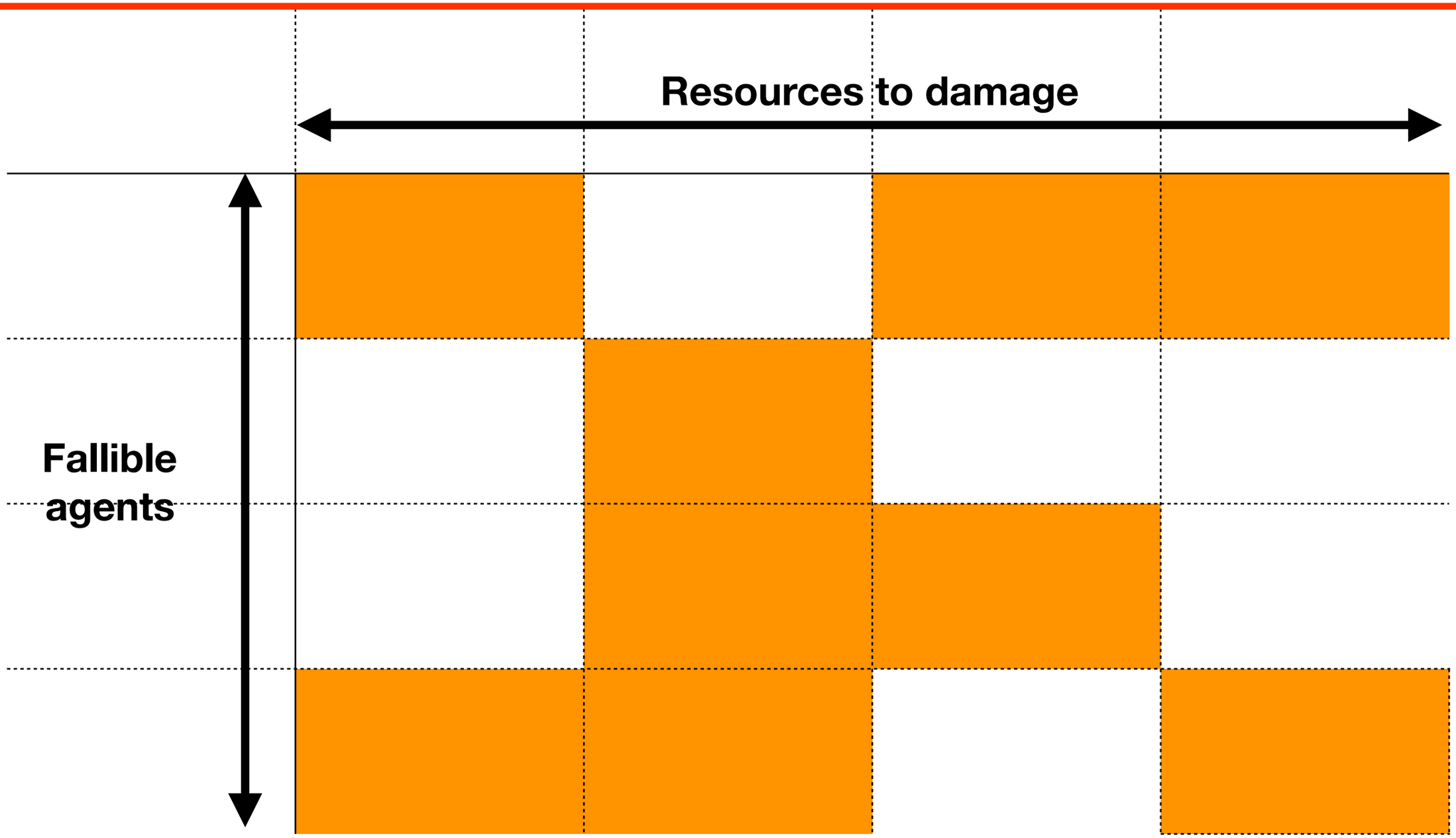
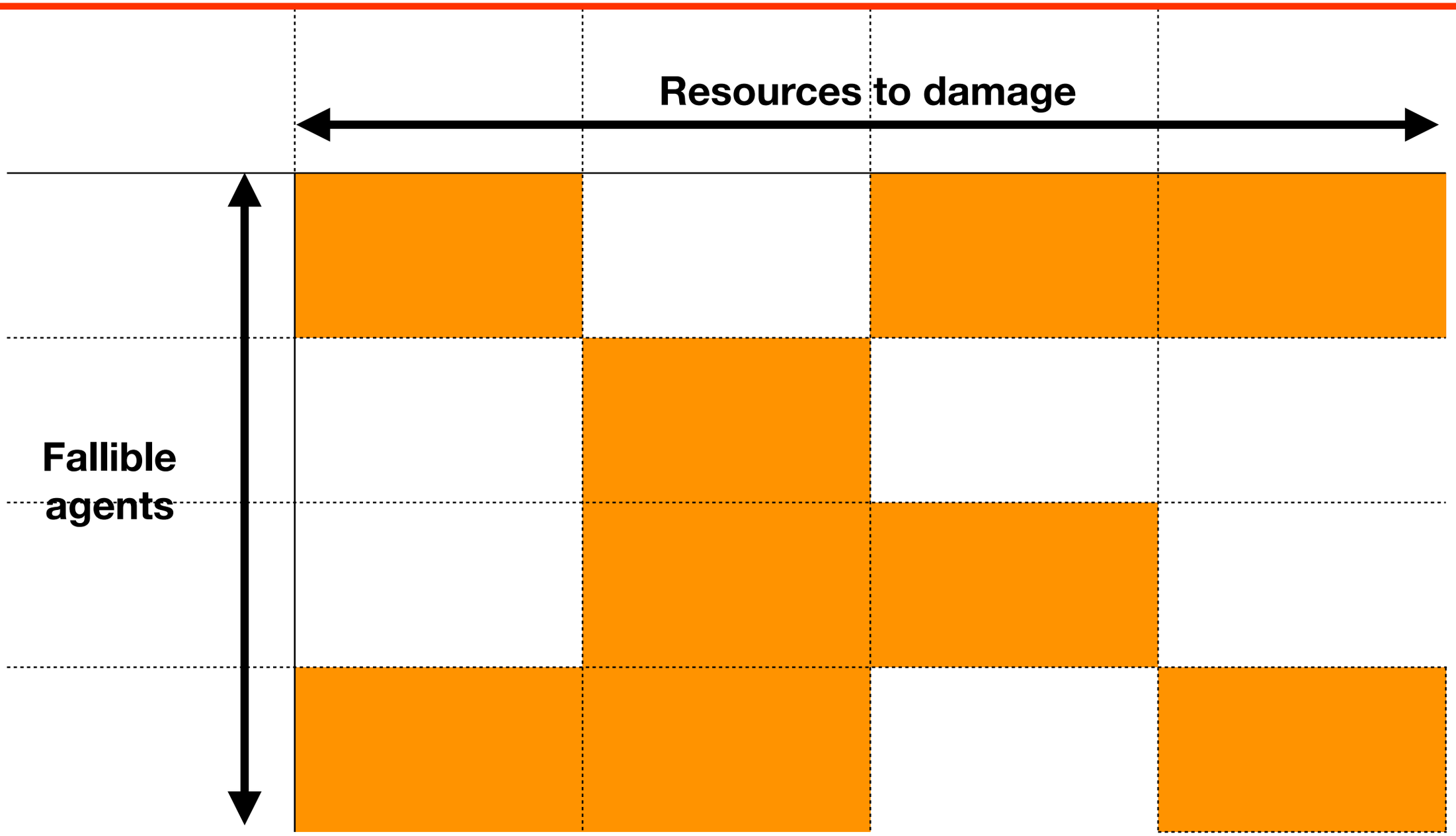


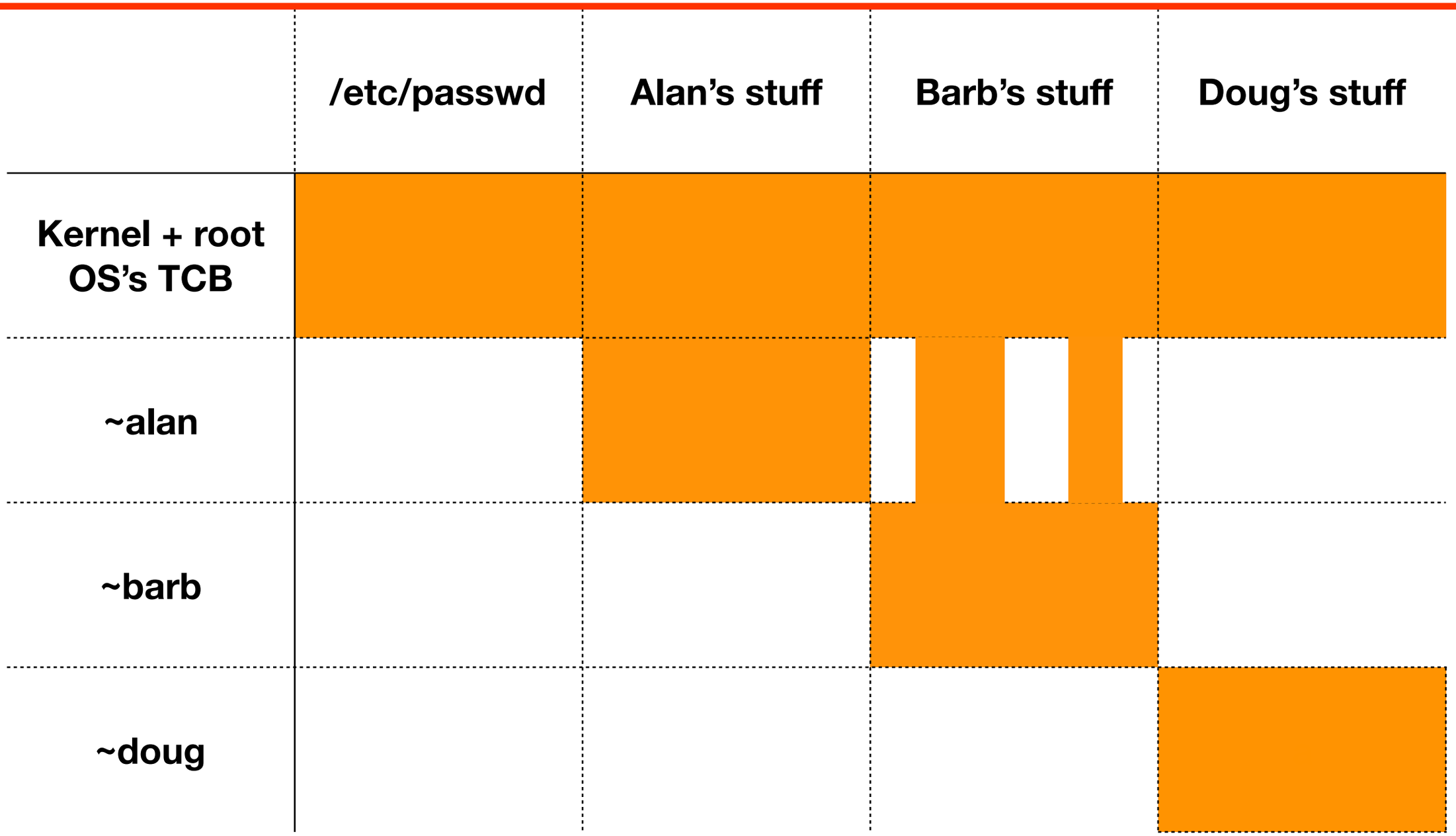
Access Matrix
Permission or Authority?

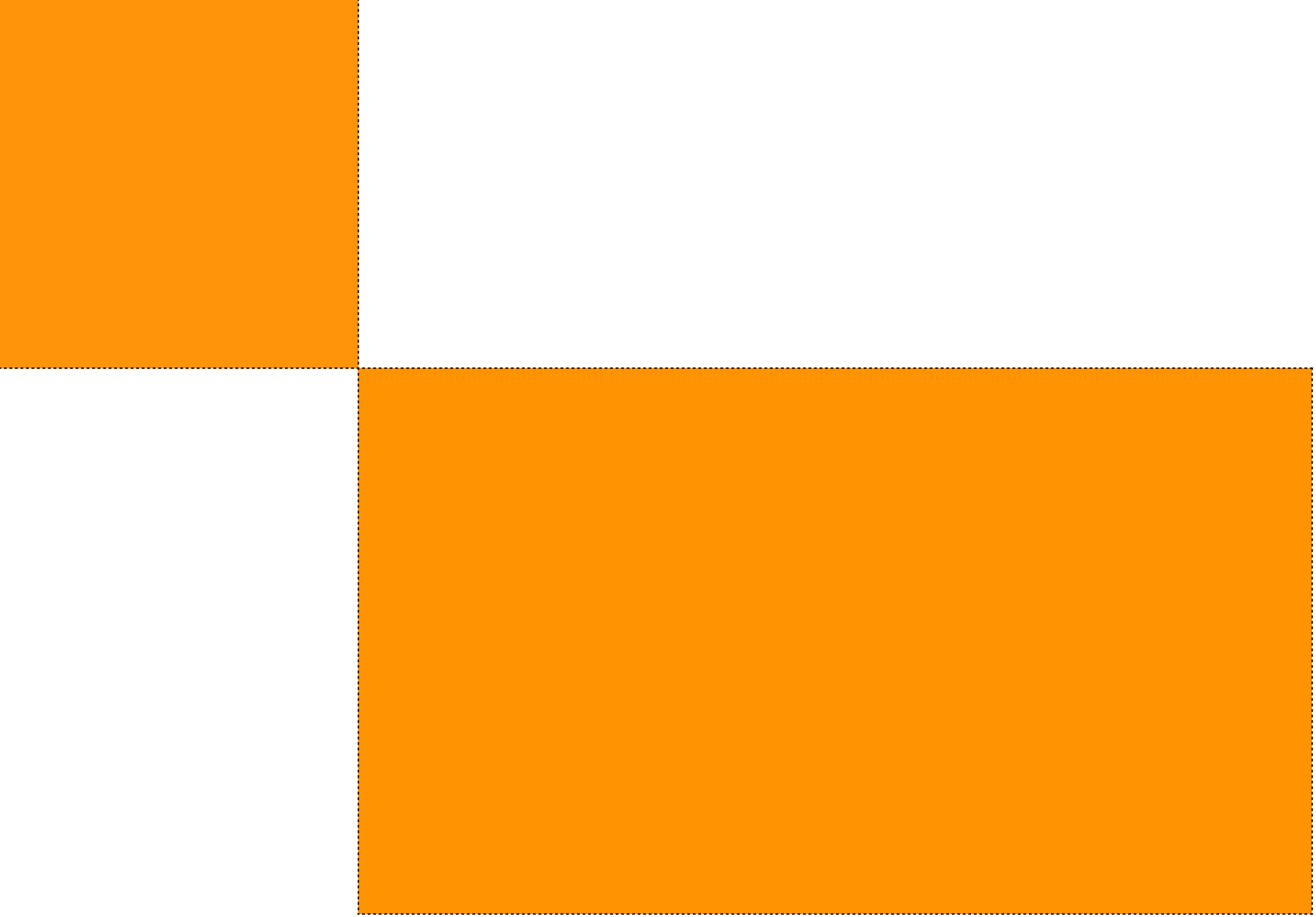


Hollow Out the Attack Surface!

	/etc/passwd	Alan's stuff	Barb's stuff	Doug's stuff
Kernel + root OS's TCB				
~alan				
~barb				
~doug				

Decouple accounts





Decouple applications

	contact info	pgp keyring	calc.xls	Net access
Shell, Desktop				
Browser				
Spreadsheet				
Email client				

Decouple apps

	contact info	pgp keyring	calc.xls	Net access
MobileOS Doug's TCB				
Browser app				
Spreadsheet doc				
Mail app				

Decouple apps

	contact info	pgp keyring	calc.xls	Net access
MobileOS Doug's TCB	■	■	■	■
Browser app			■	■
Spreadsheet doc			■	
Mail app	■	■		■

Substrate	Historical System	System
Hardware	CMNM, Plessey 250, C.mmp, CM*, CAP, Flex, IBM System/38, Intel 432	Crash-SAFE, CHERI, Risc-V
OS	DVH, Hydra, StarOS, RATS, Cal-TSS, PSOS, NLTSS, Spring	Capsicum, CloudABI, Genode, Barrelfish, Fuchsia
KeyKOS family OS	Gnosis, KeyKOS, GuardOS, EROS, CapROS, Coyotos	seL4
Distributed OS	Ameoba, Mach, Midori	
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User Interface	CapDesk, Scoopfs, Belay	Sandstorm

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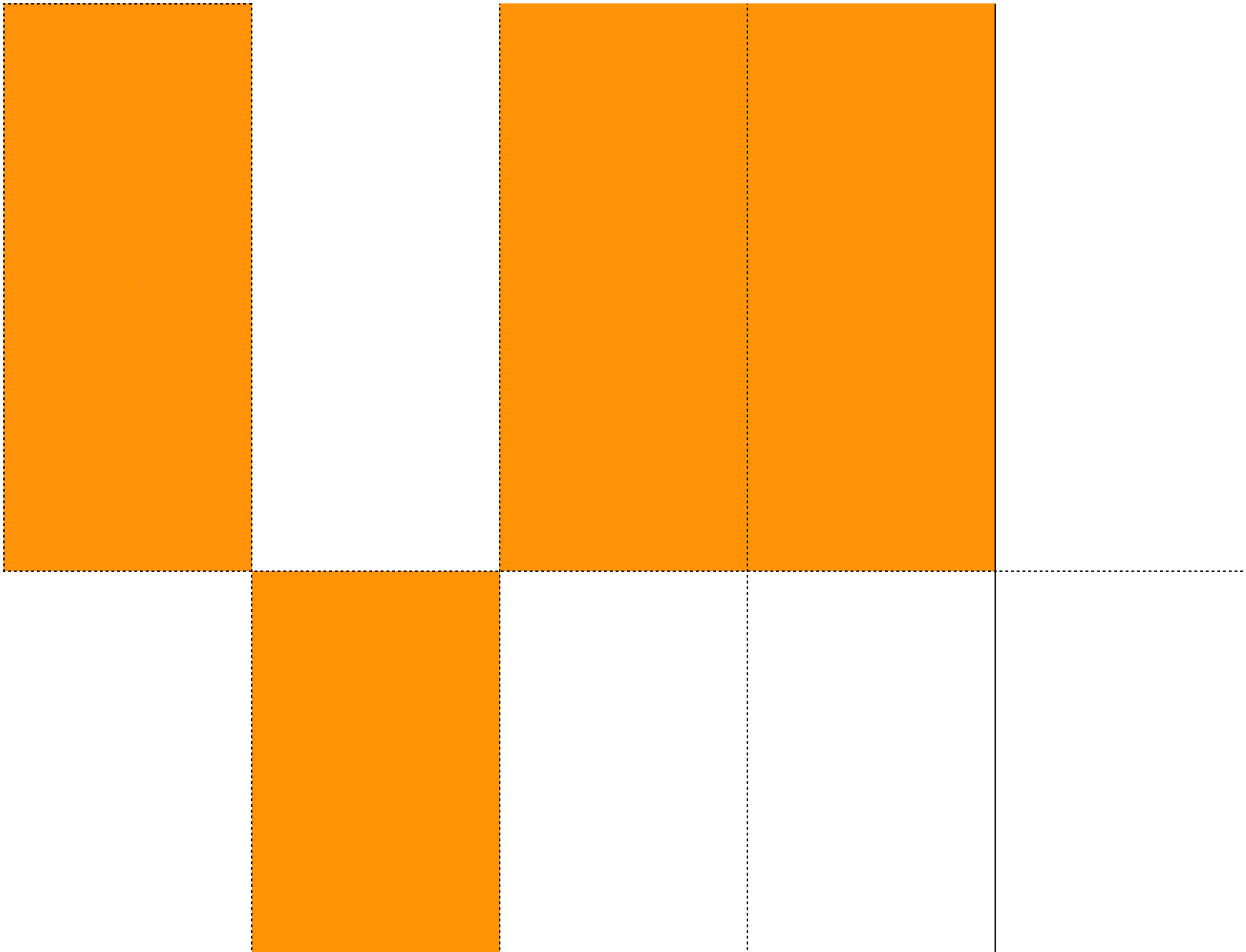
Decouple caplets

	contact info	pgp keyring	calc.xls	Net access
E, CapDesk Doug's TCB	■	■	■	■
DarpaBrowser caplet				■
Excel in Polaris			■	
CapMail caplet	■	■		■



Decouple modules

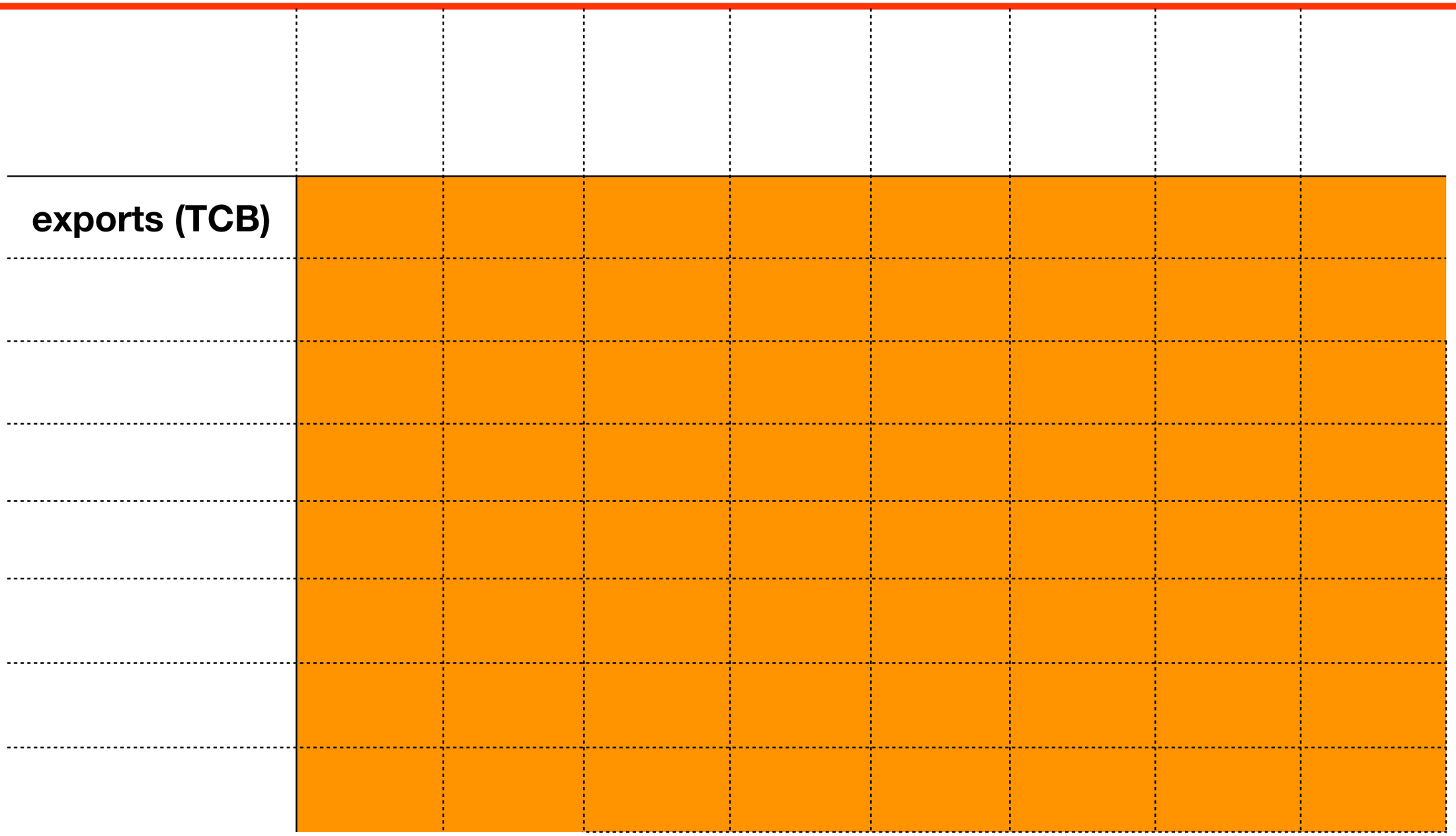
	contact info	pgp keyring	calc.xls	Net access
main() CapMail's TCB	■	■		■
address book	■	■		■
gpg plugin	■	■		■
SMTP, POP stacks	■	■		■

Decouple modules

	contact info	pgp keyring	calc.xls	Net access
main() CapMail's TCB	■	■		■
address book	■			
gpg plugin	■	■		
SMTP, POP stacks				■

n

Decouple objects



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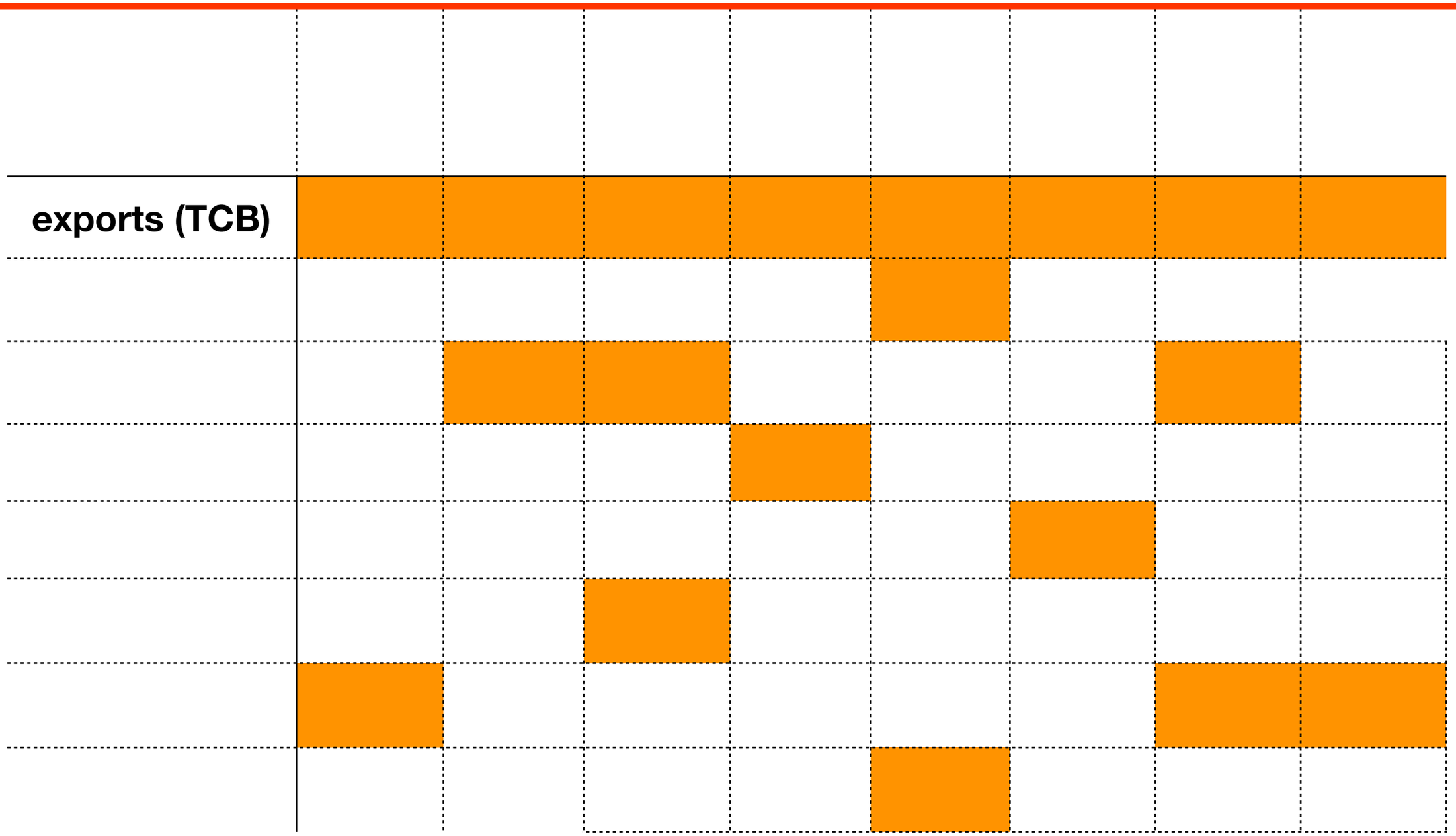
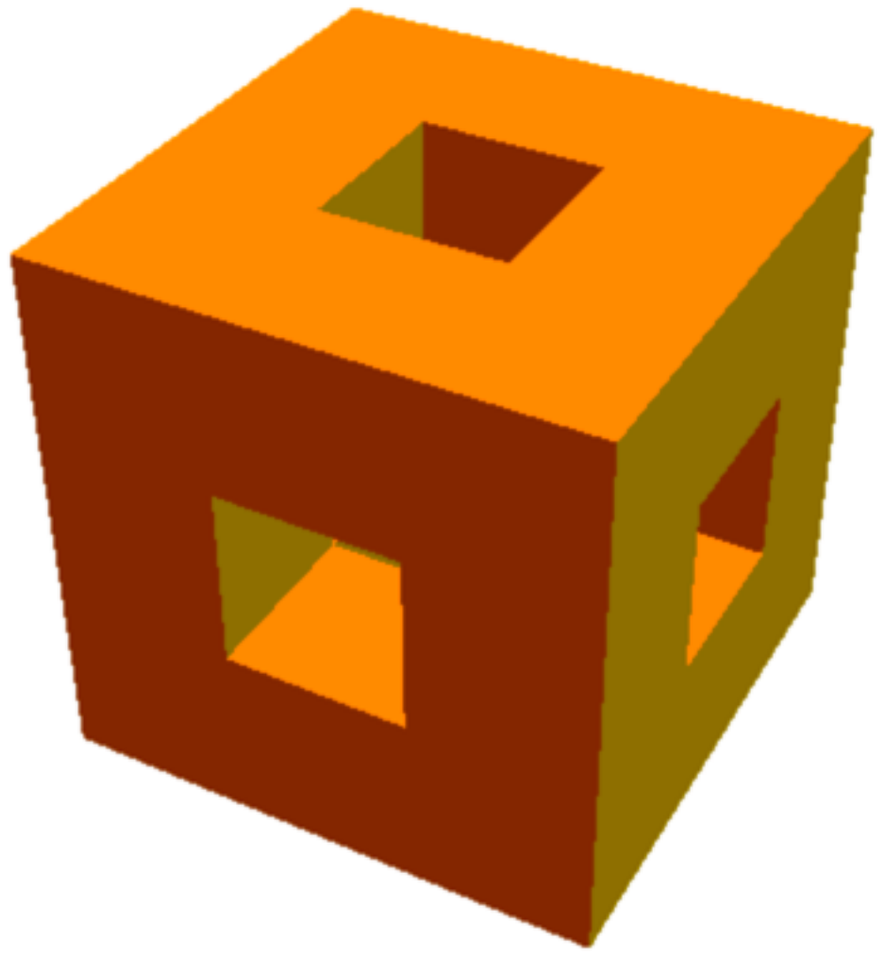
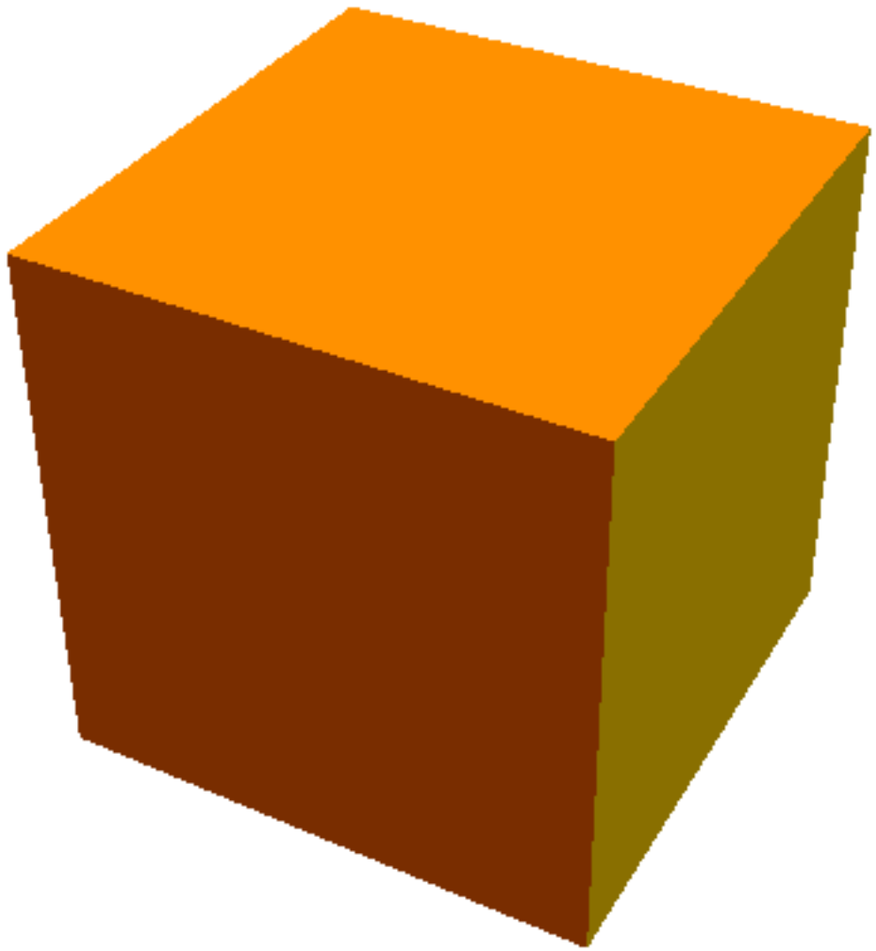


Defensive Programming



Defense in Depth



Reduce area
Mix of strategies

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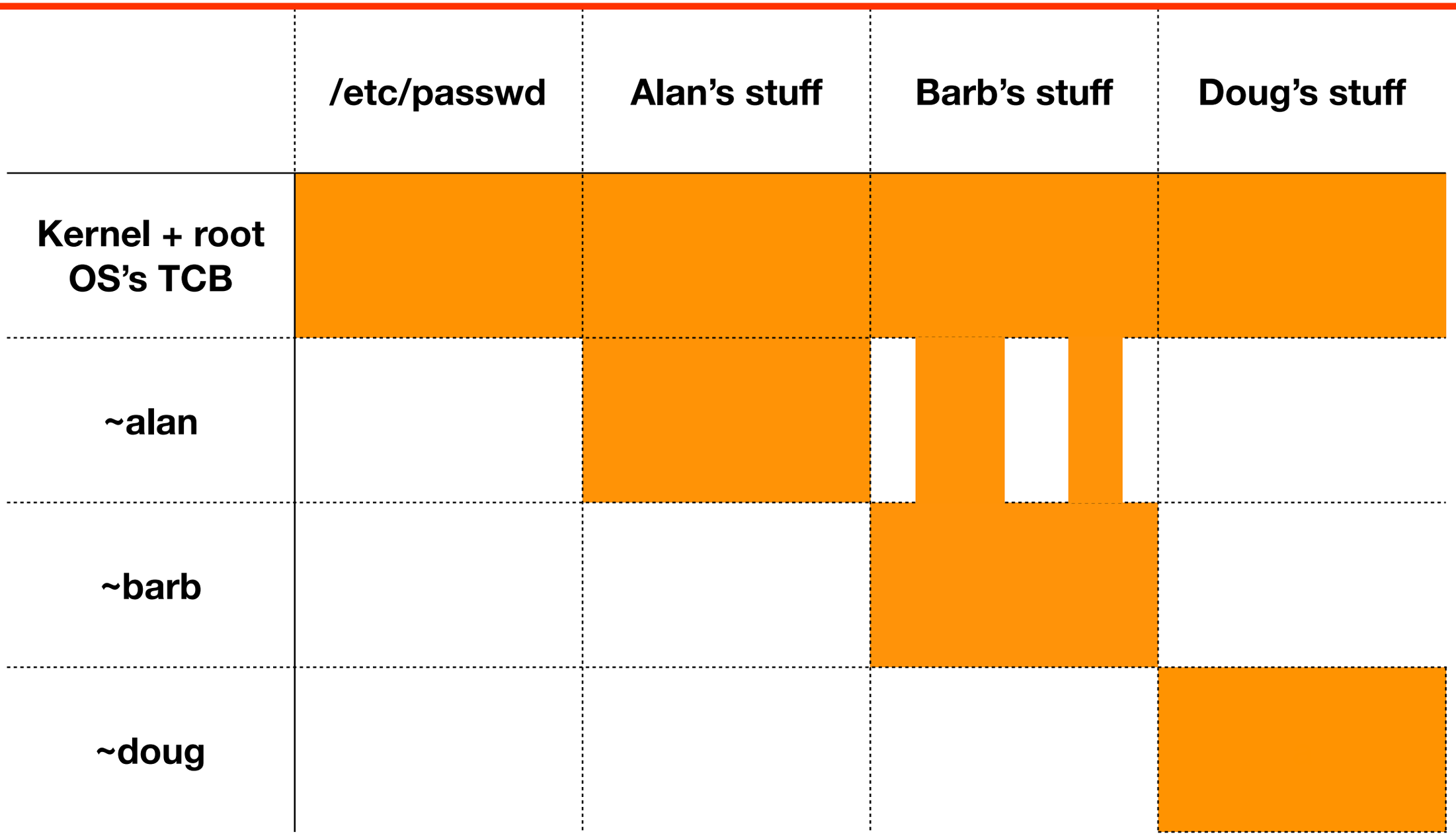
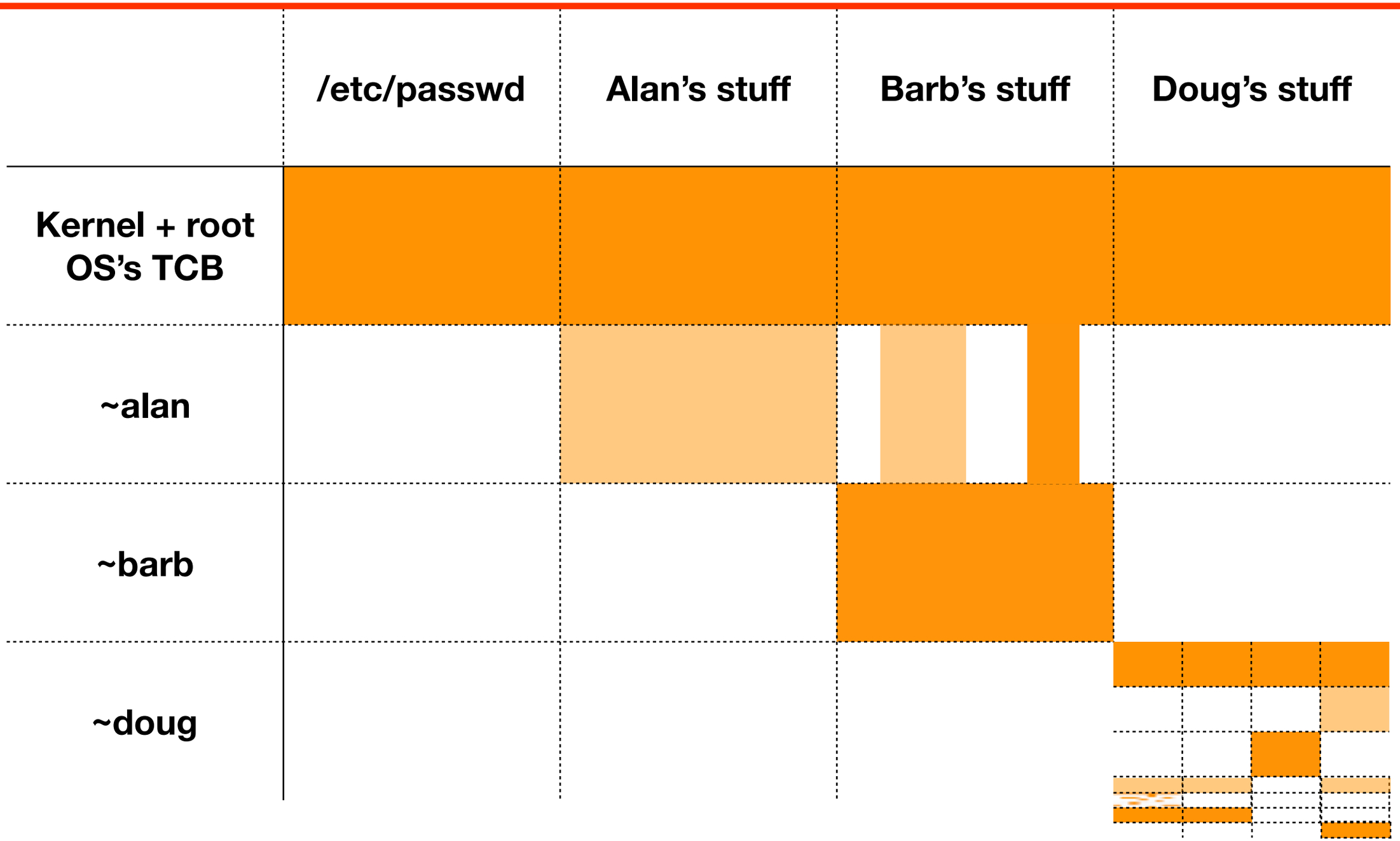
Kernel + root OS's TCB				
~alan				
~barb				
~doug				

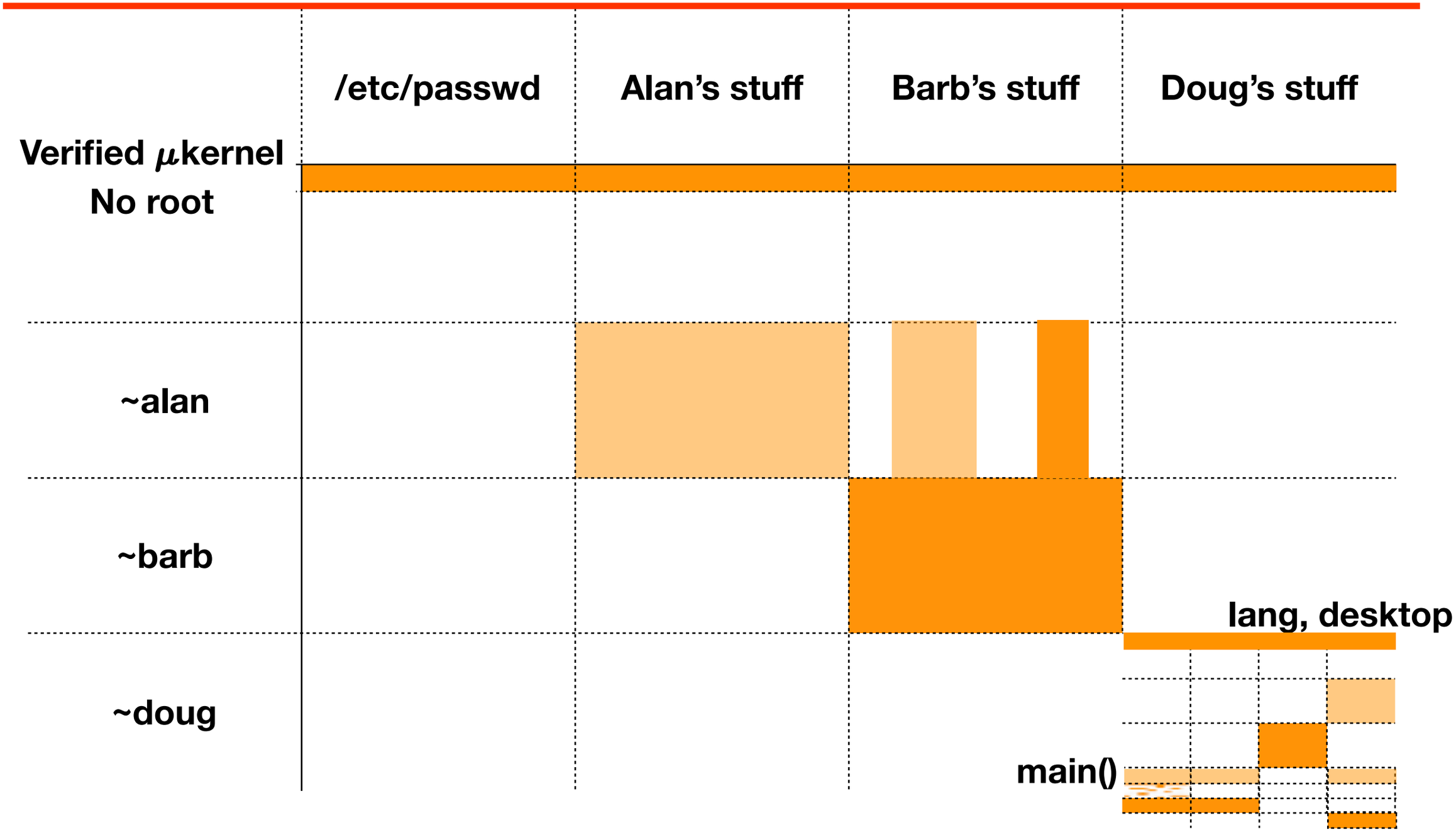
Reduce horizontal space
POLA — Principle of Least Authority



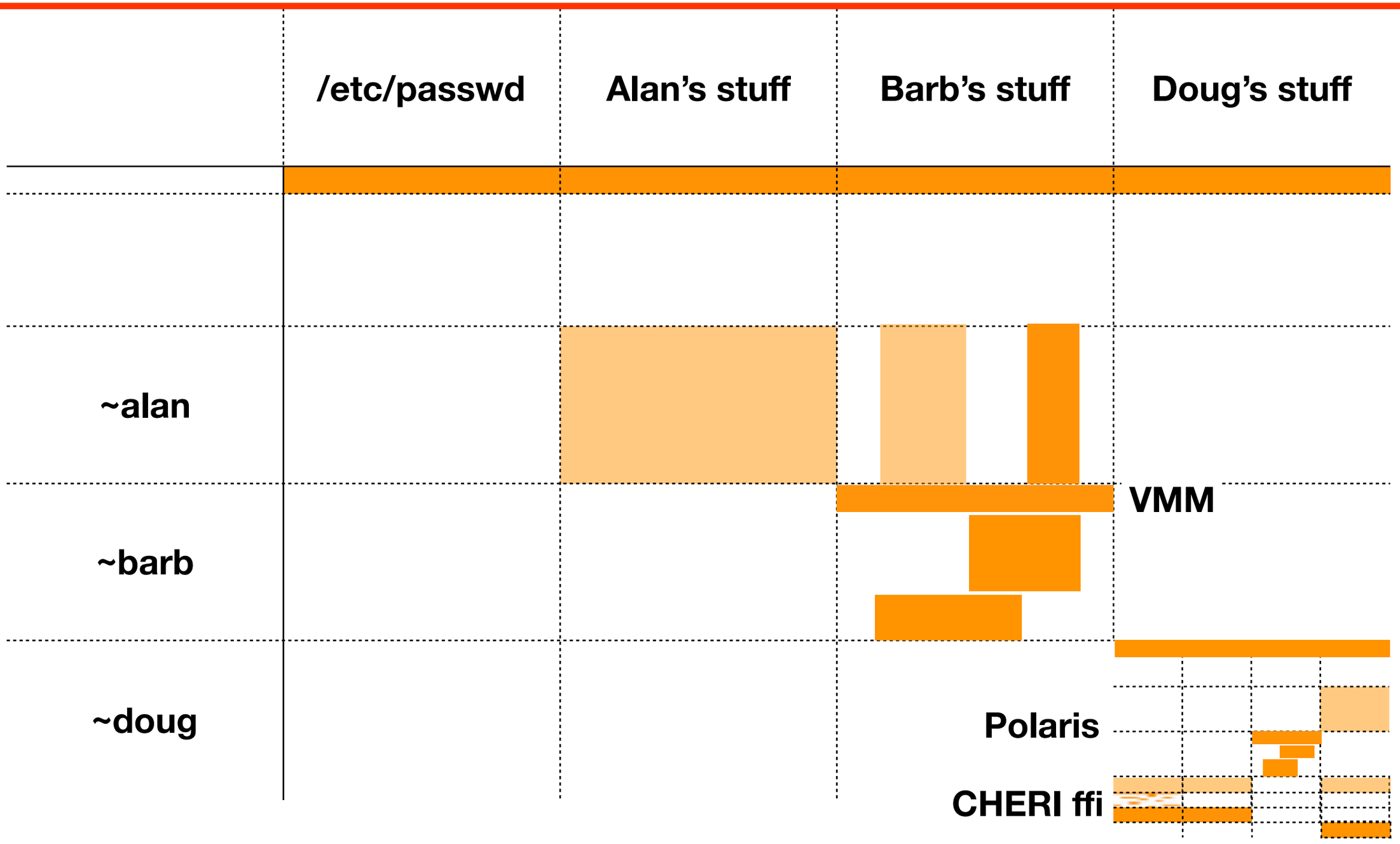
Reduce density
Apply POLA recursively



Reduce height
Minimize+verify each TCB



Reduce width
Partition virtualized legacy



Multiplicative risk reduction

Reduce horizontal space	POLA
Reduce density	Composition across scales
Reduce height	Minimize TCBs: μkernel, lang, …
Reduce width	Compositional virtualization

Choose Verification Battles

Reduce horizontal space	POLA Patterns limit authority?
Reduce density	Composition across scales Embedding preserves security?
Reduce height	Minimize TCBs: μkernel, lang, … **Formal verification**
Reduce width	Compositional virtualization Impenetrable confinement?

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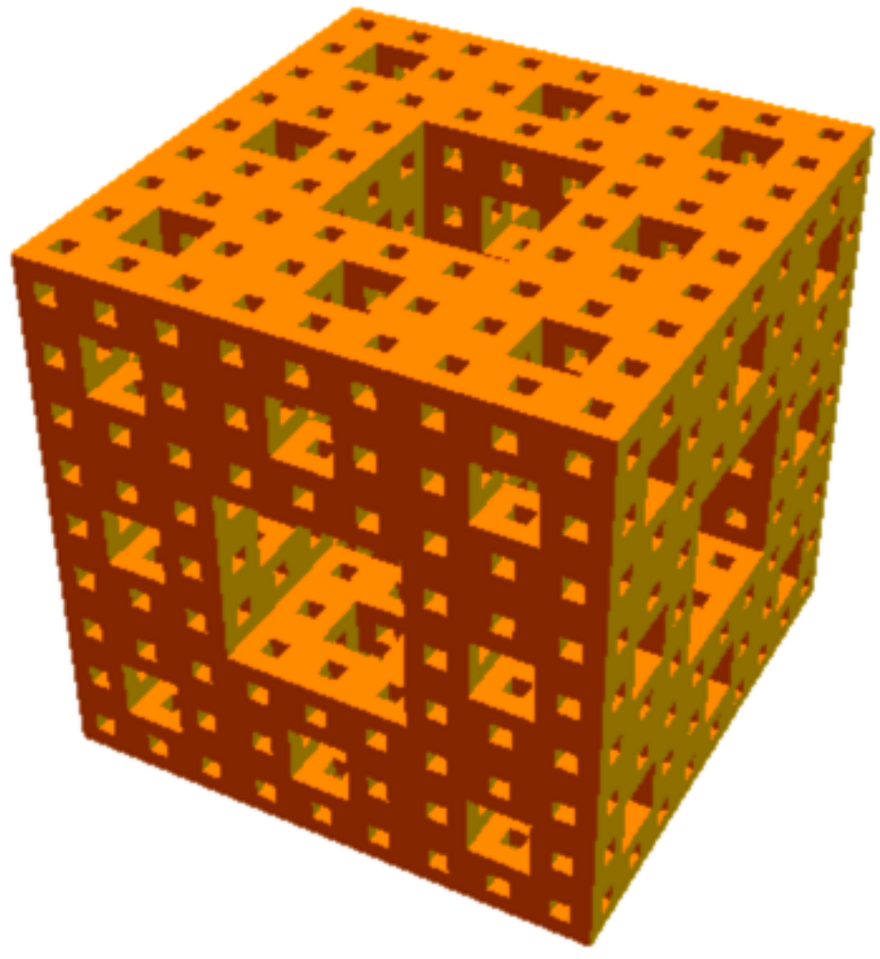
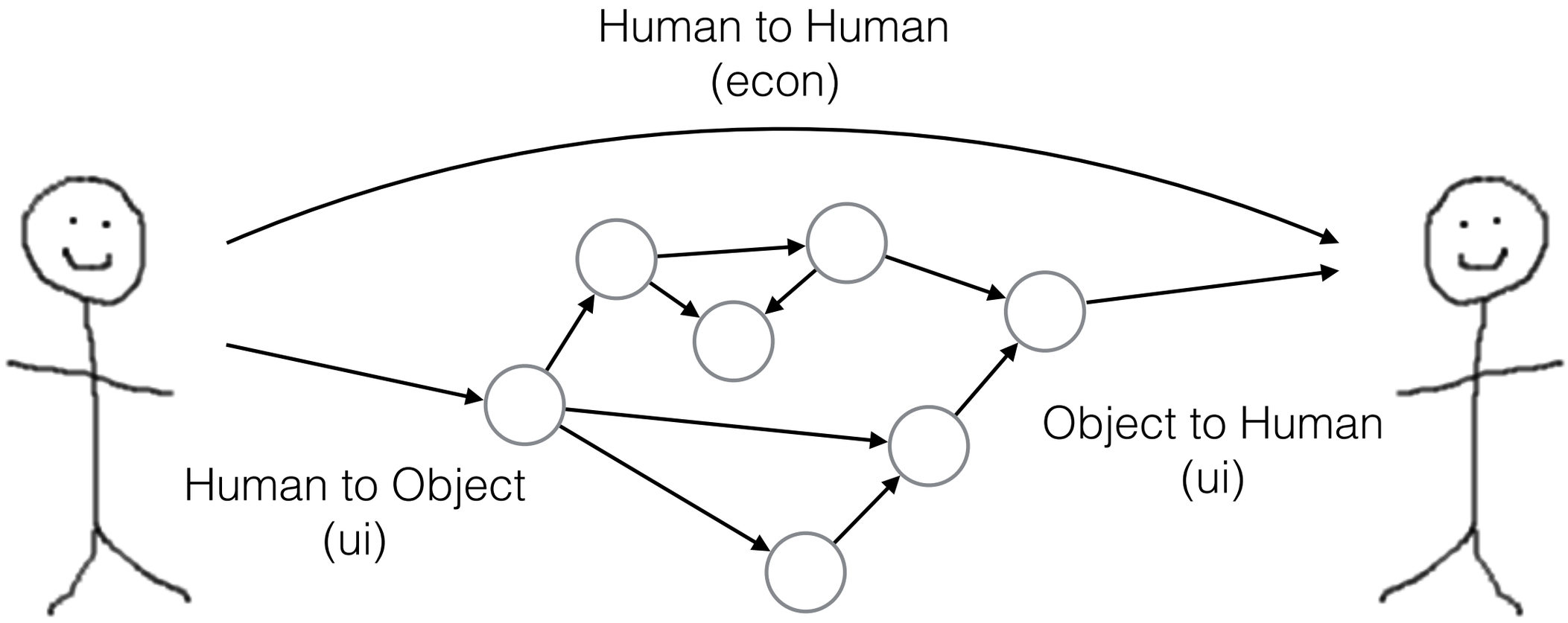
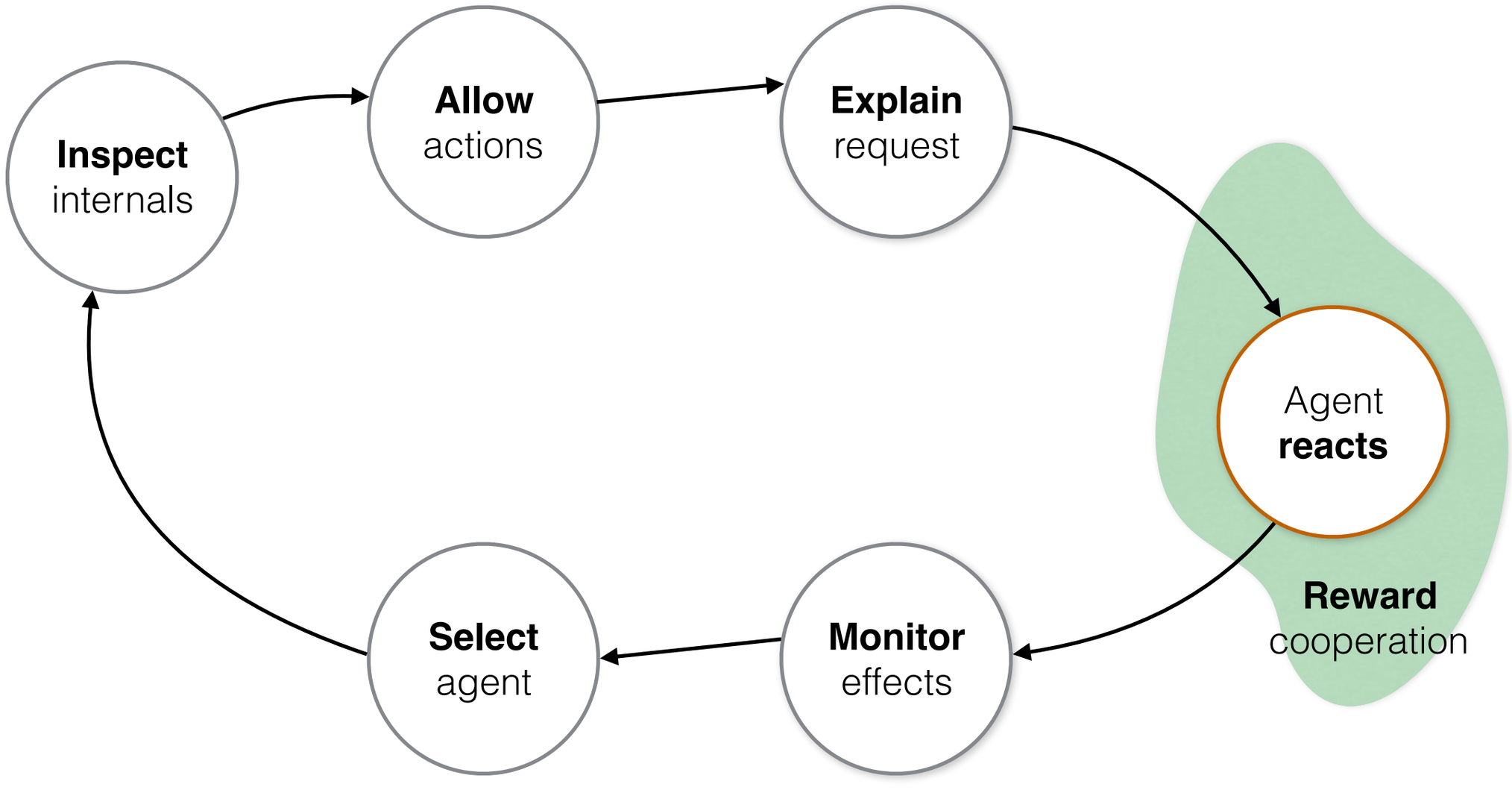
Questions?



Networks of request making



The Principal-Agent Loop



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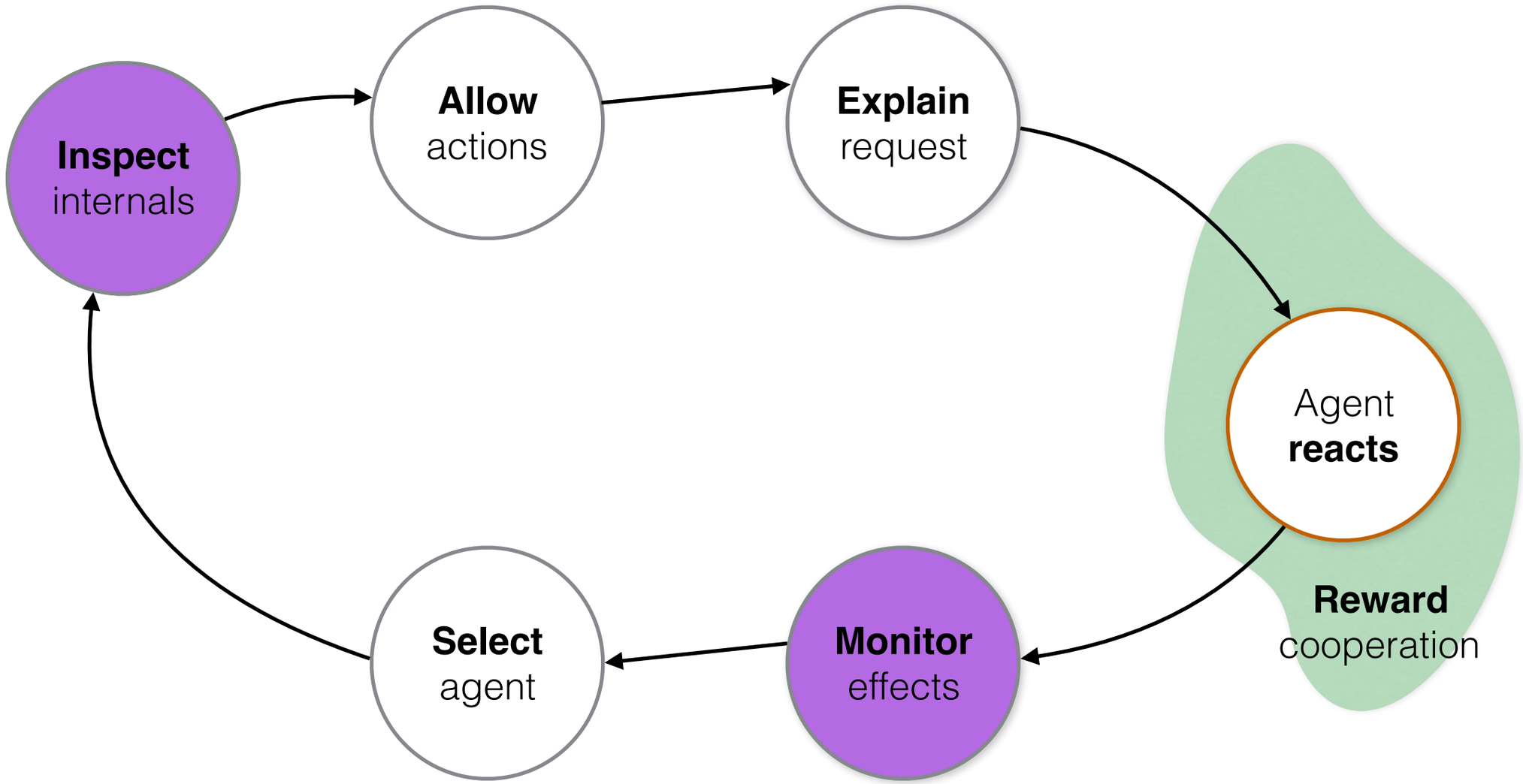

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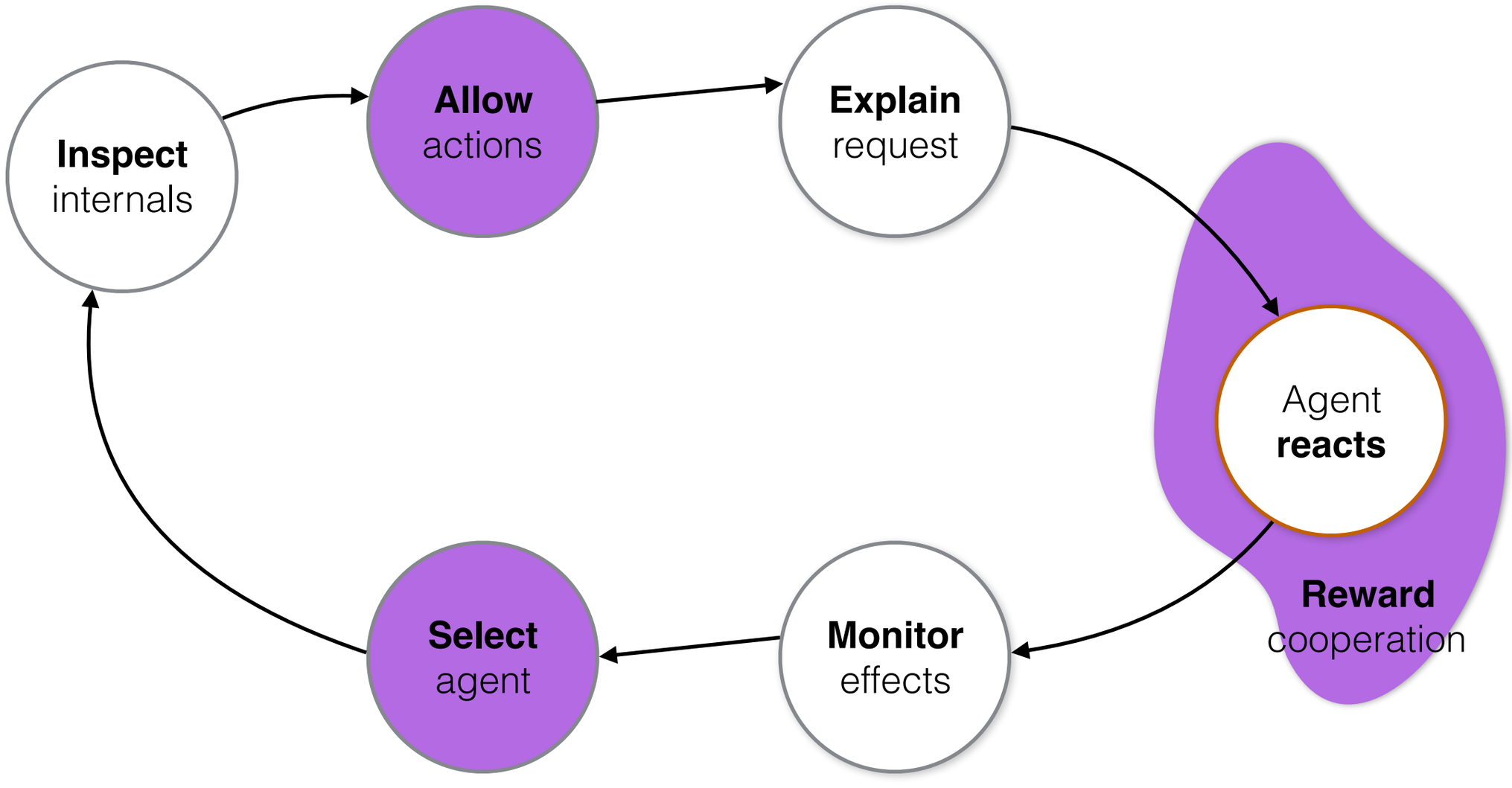

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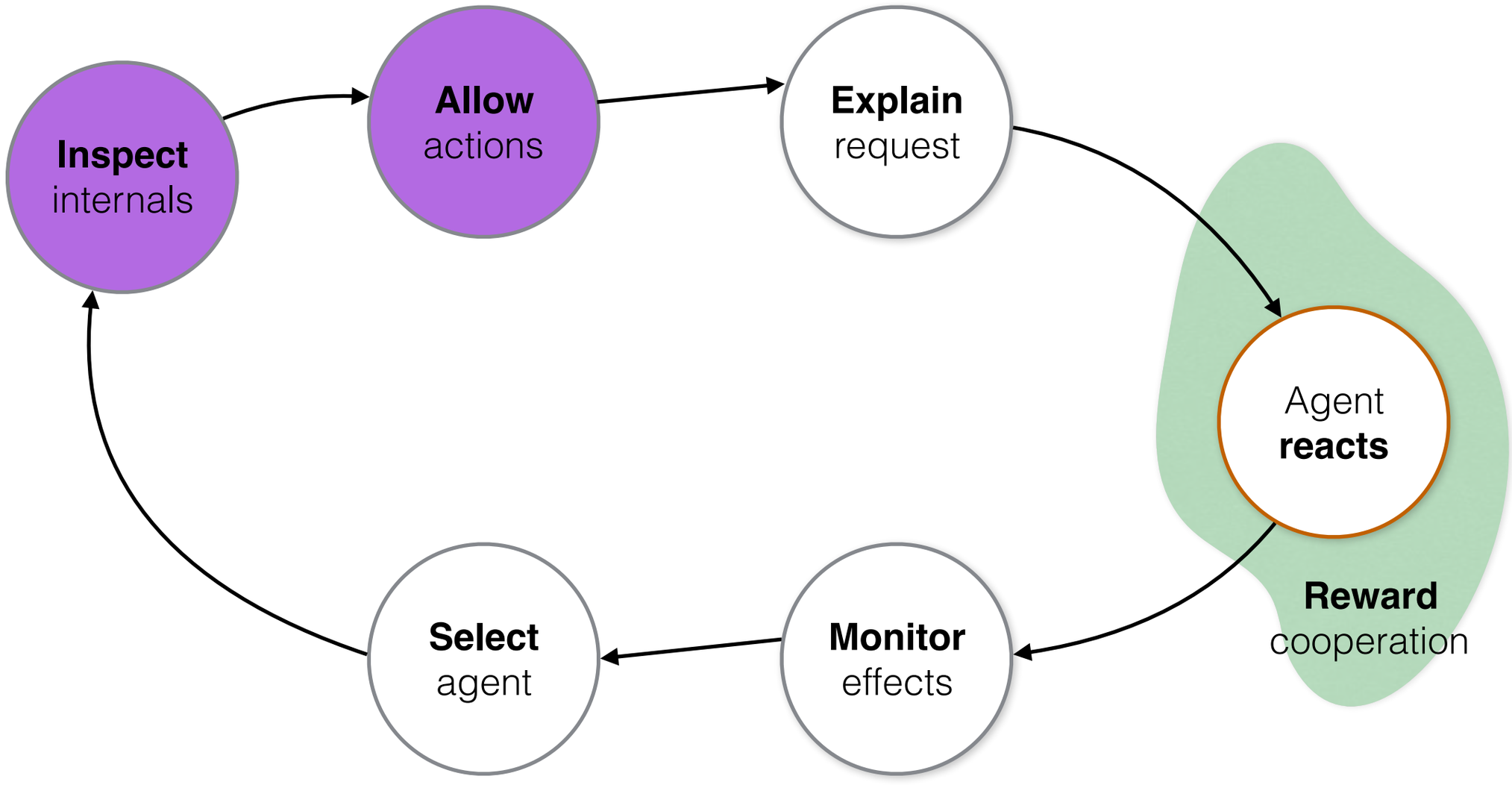

The Elements of Decision Alignment

	Human to Human	Human to/from Object	Object to Object
Select agent	Trademark Chain of custody	App stores White and black lists	Trusted developer Same origin
Inspect internals	Accounting controls	Trusted path URL bar	Types, Verification Open source eyeballs
Allow actions	Law, Contracts	App permissions Powerbox	Security Protection patterns
Explain request	Language	User interface	Abstraction
Reward cooperation	Economics Incentive Alignment	Objective functions	Machine learning Agorics
Monitor effects	Reviews, Complaints Word of mouth	Bug reports	Contracts, Testing Backprop

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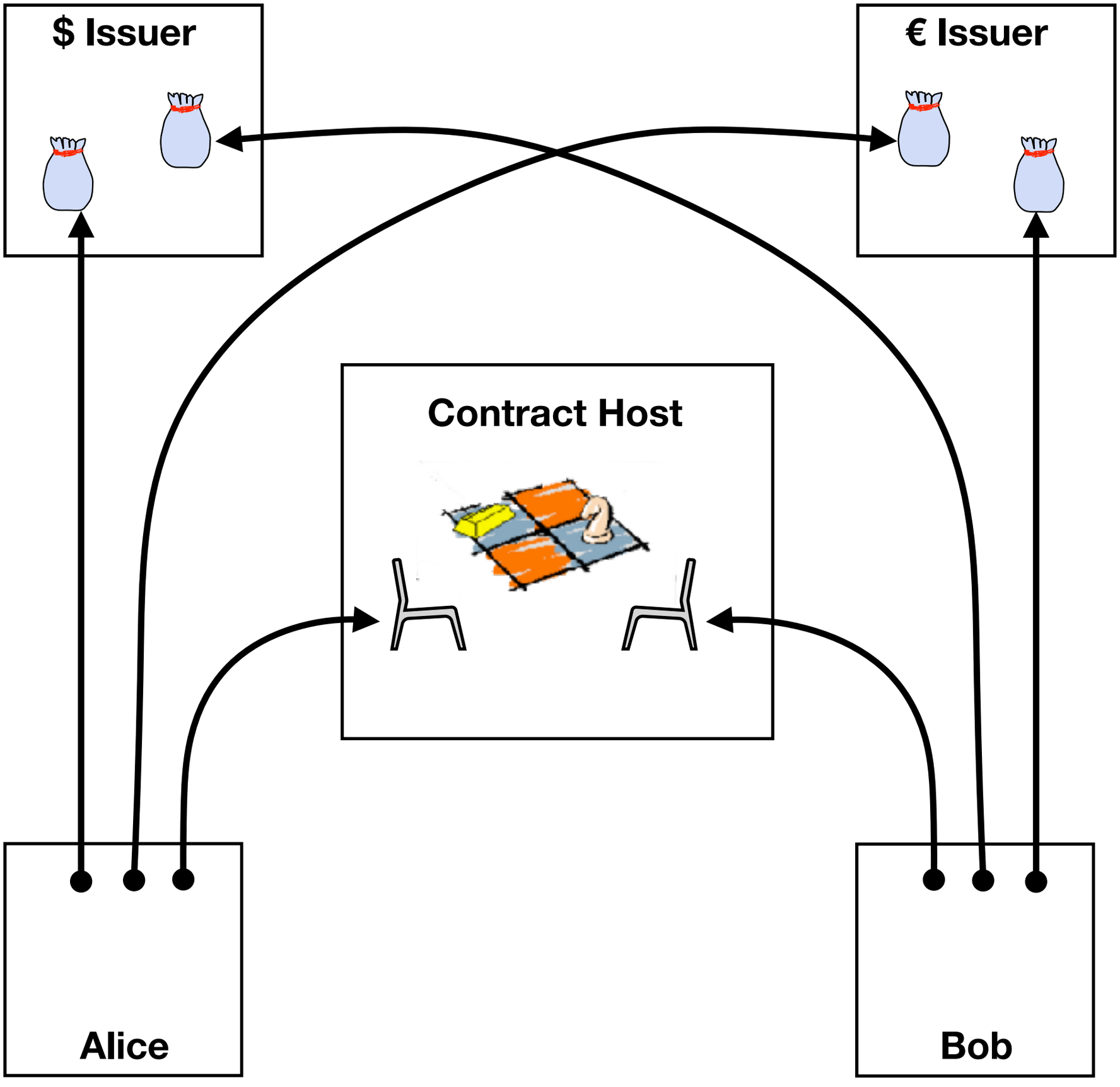
Escrow Exchange Contract

```
function escrowExchange(a, b) {                          // a from Alice, b from Bob
  let decide;
  const decisionP = new Promise(resolve => { decide = resolve; });

  function transfer(srcPurseP, dstPurseP, amount) {
    const makeEscrowPurseP = Q.join(srcPurseP ! makePurse,
                                    dstPurseP ! makePurse);
    const escrowPurseP = makeEscrowPurseP ! ();
    Q(decisionP).then(                                   // setup phase 2
      _ => dstPurseP ! deposit(amount, escrowPurseP); },
      _ => srcPurseP ! deposit(amount, escrowPurseP); });

    return escrowPurseP ! deposit(amount, srcPurseP);    // phase 1
  }
  async function failOnly(cancellationP) { throw await cancellationP; }

  decide(Promise.race([Promise.all([
      transfer(a.moneySrcP, b.moneyDstP, b.moneyNeeded),
      transfer(b.stockSrcP, a.stockDstP, a.stockNeeded)
    ]),
    failOnly(a.cancellationP),
    failOnly(b.cancellationP)]));
  return decisionP;
}
```


$ Issuer
€ Issuer
Contract Host
Alice
Bob

Substrate Independent Cap Logic

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