Dependability and its Threats: A Taxonomy

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Dependability: ability to deliver service that can justifiably be trusted

Service delivered by a system: its behavior as it is perceived by its user(s)

User: another system that interacts with the former

Function of a system: what the system is intended to do

(Functional) Specification: description of the system function

Correct service: when the delivered service implements the system function

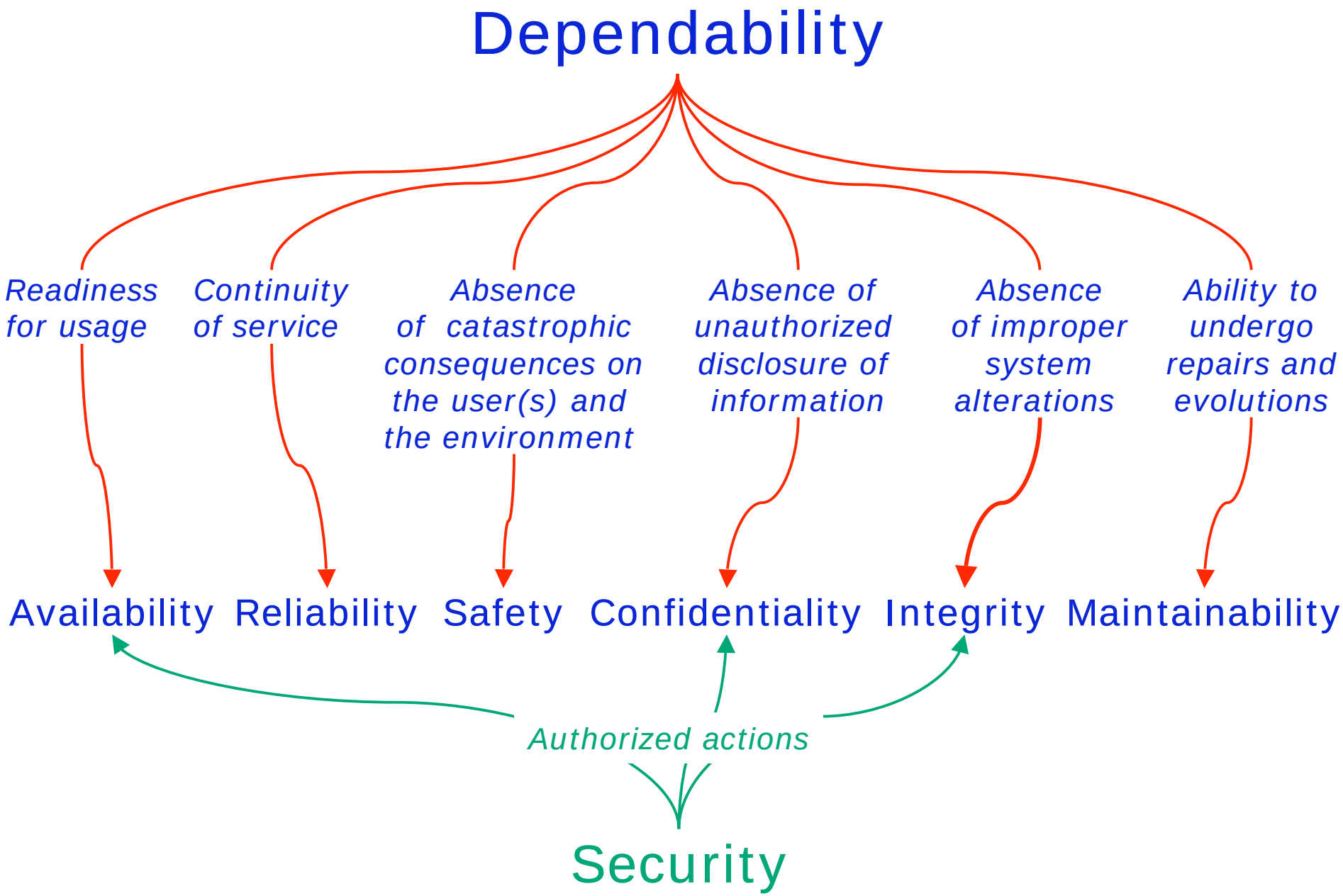
Service failure: event that occurs when the delivered service deviates from correct service, either because the system does not comply with the specification, or because the specification did not adequately describe its function

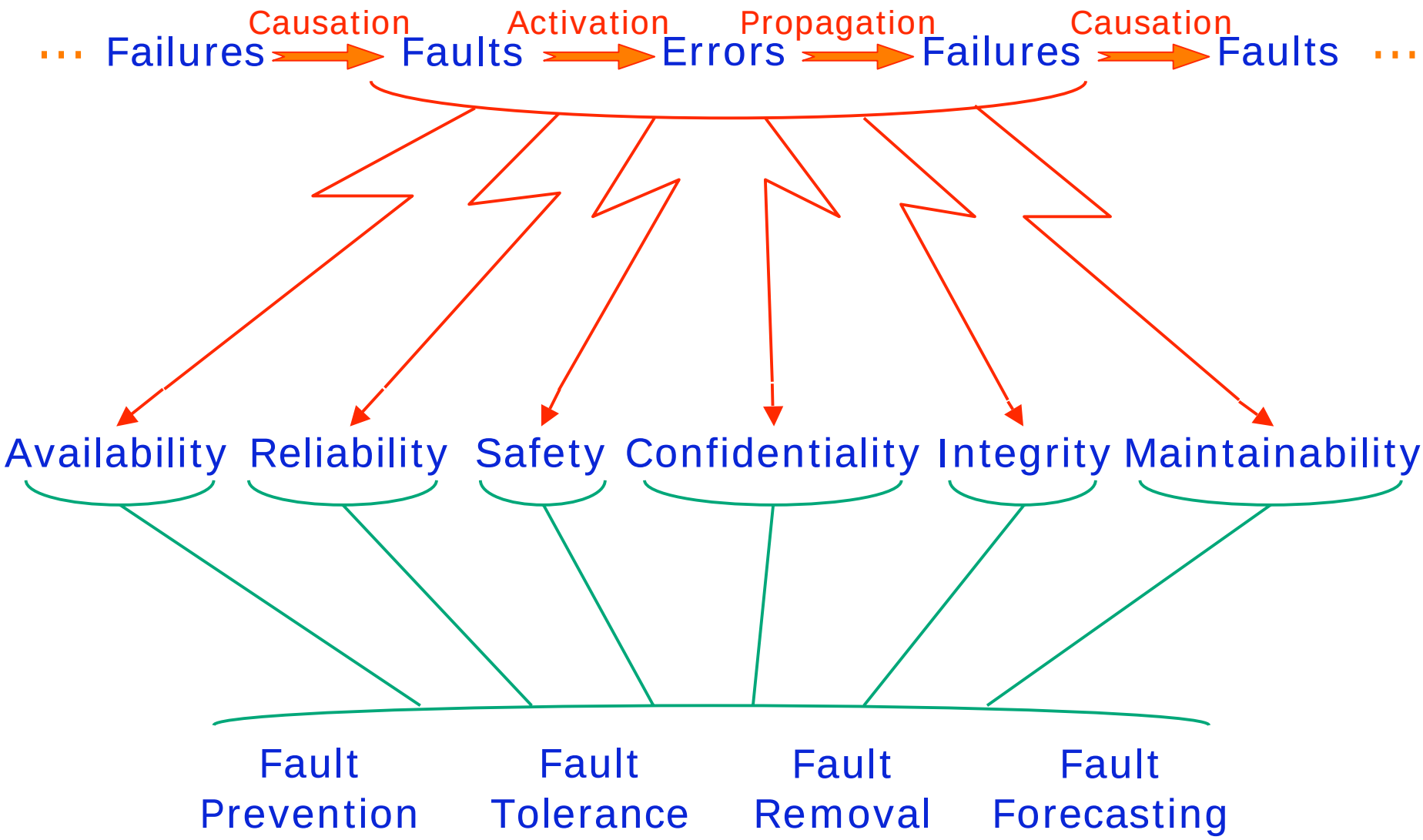
Failure modes: the ways in which a system can fail, ranked according to failure severities

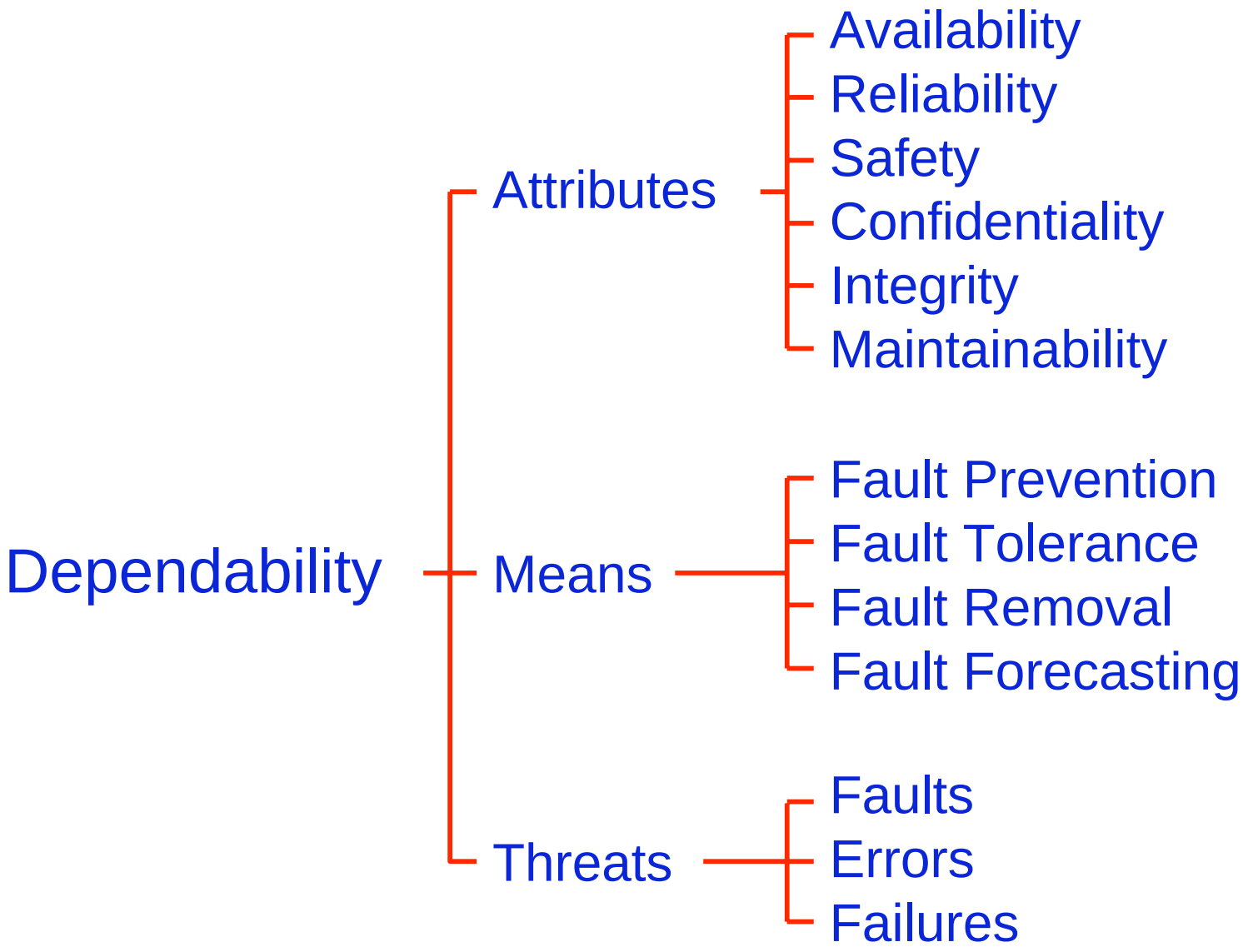
Part of system state that may cause a subsequent service failure: error
Adjudged or hypothesized cause of an error: fault

Dependability: ability to avoid service failures that are more frequent or more severe than is acceptable

When service failures are more frequent or more severe than acceptable: dependability failure


Dependability
Readiness for usage
Continuity of service
Absence of catastrophic consequences on the user(s) and the environment
Absence of unauthorized disclosure of information
Absence of improper system alterations
Ability to undergo repairs and evolutions
Availability
Reliability
Safety
Confidentiality
Integrity
Maintainability
Authorized actions
Security
Absence of unauthorized access to, or handling of, system state

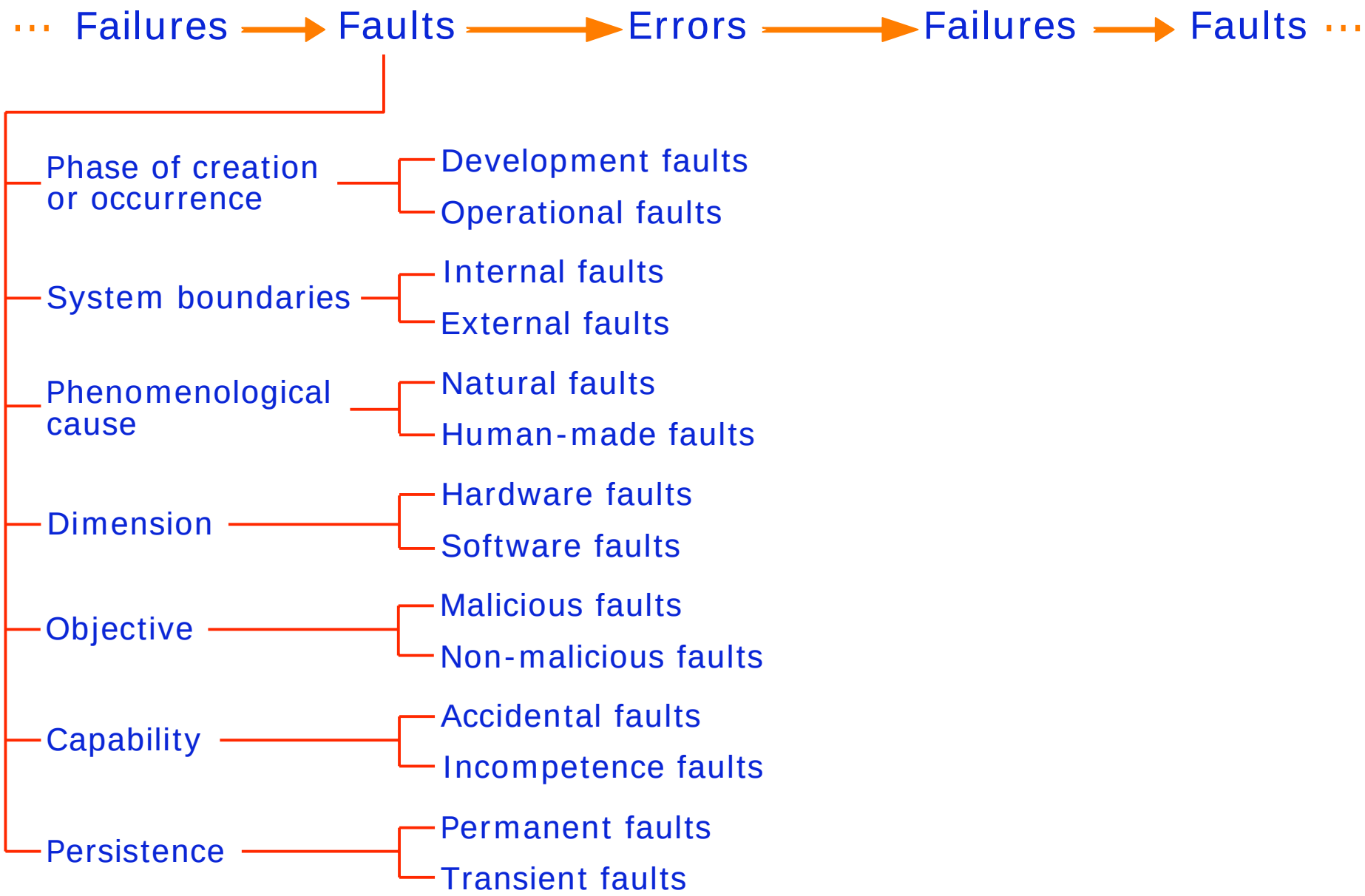

Causation
Activation
Propagation
Causation
... Failures
Faults
Errors
Failures
Faults ...
Availability
Reliability
Safety
Confidentiality
Integrity
Maintainability
Fault Prevention
Fault Tolerance
Fault Removal
Fault Forecasting

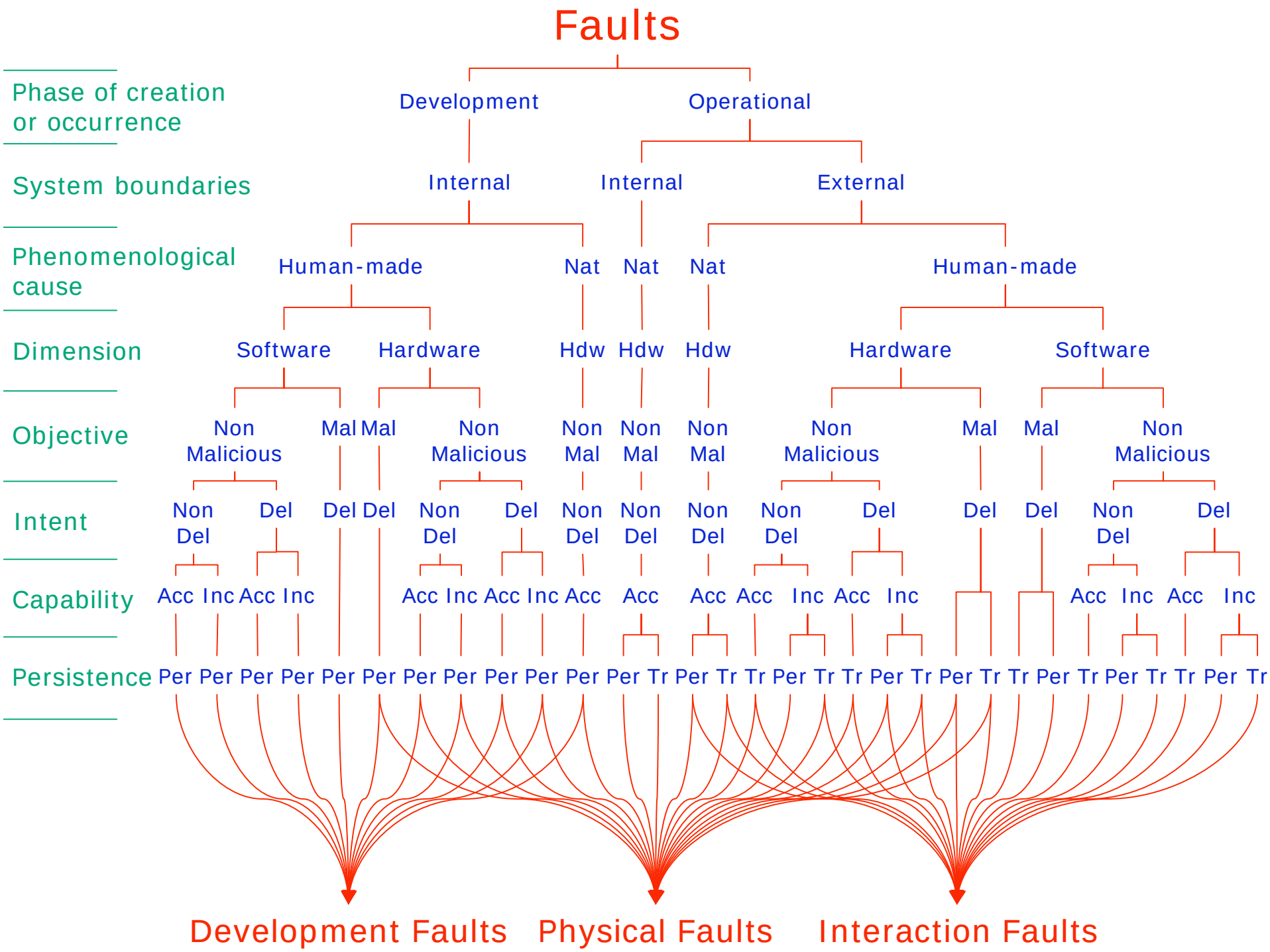

Dependability
Attributes
Availability
Reliability
Safety
Confidentiality
Integrity
Maintainability
Means
Fault Prevention
Fault Tolerance
Fault Removal
Fault Forecasting
Threats
Faults
Errors
Failures

Situation

- ✓ Relationship between dependability and security
- ✓ Alternate definition of dependability
- ✓ Service failures distinguished from dependability failures
- ➢ Expanded classification of faults, including criterion of capability in the classification of human-made non-malicious faults ➔ competence
- ➢ Dependability issues of the development process ➔ development failures
- ➢ Dependability related to dependence and trust
- ➢ Dependability compared with high confidence, survivability, trustworthiness

Service Threats




Faults
Phase of creation or occurrence
System boundaries
Phenomenological cause
Dimension
Objective
Intent
Capability
Persistence
Development
Operational
Internal
Internal
External
Human-made
Nat
Nat
Nat
Human-made
Software
Hardware
Hdw
Hdw
Hdw
Hardware
Software
Non Malicious
Mal
Mal
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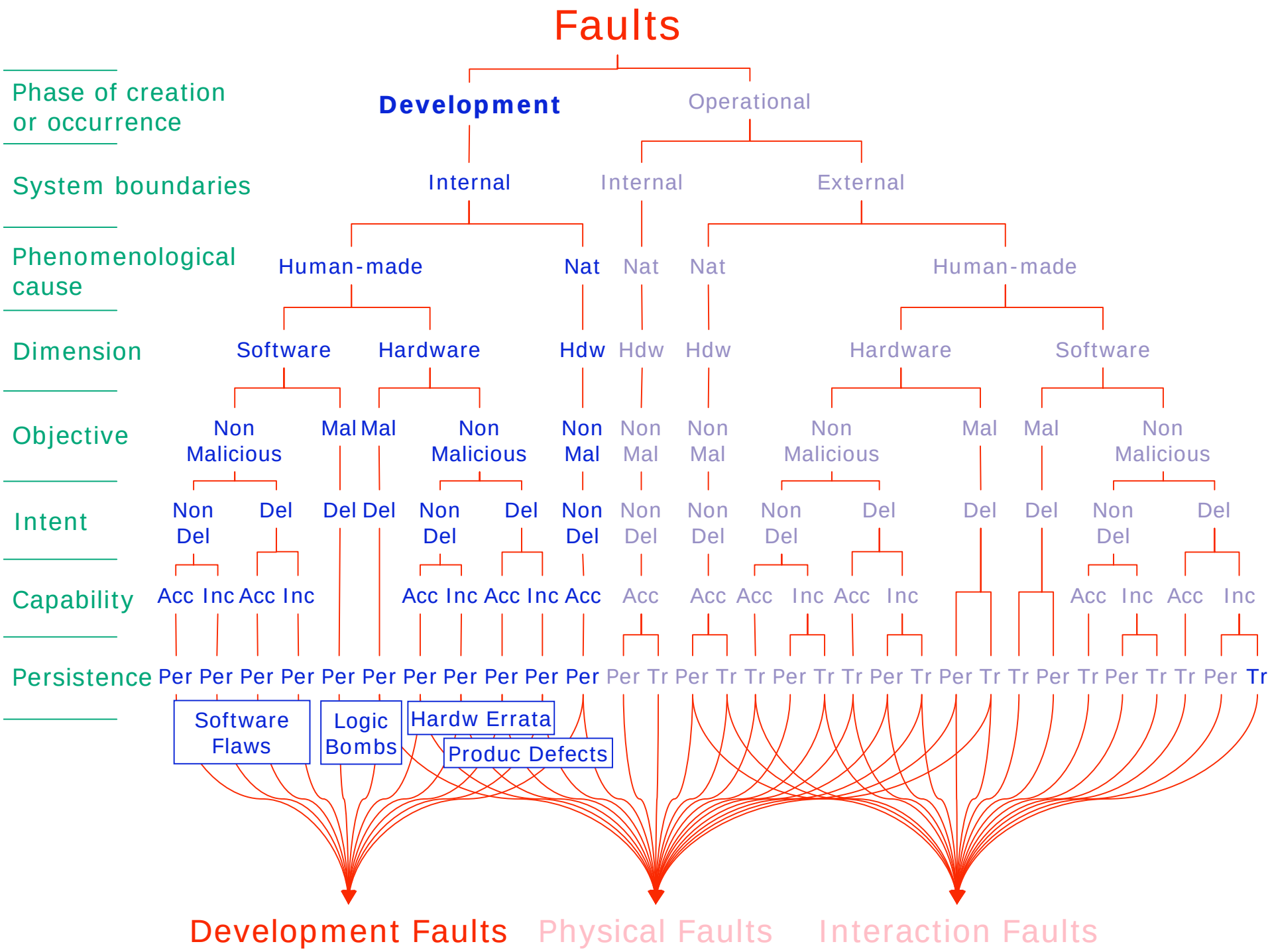
Development Faults
Physical Faults
Interaction Faults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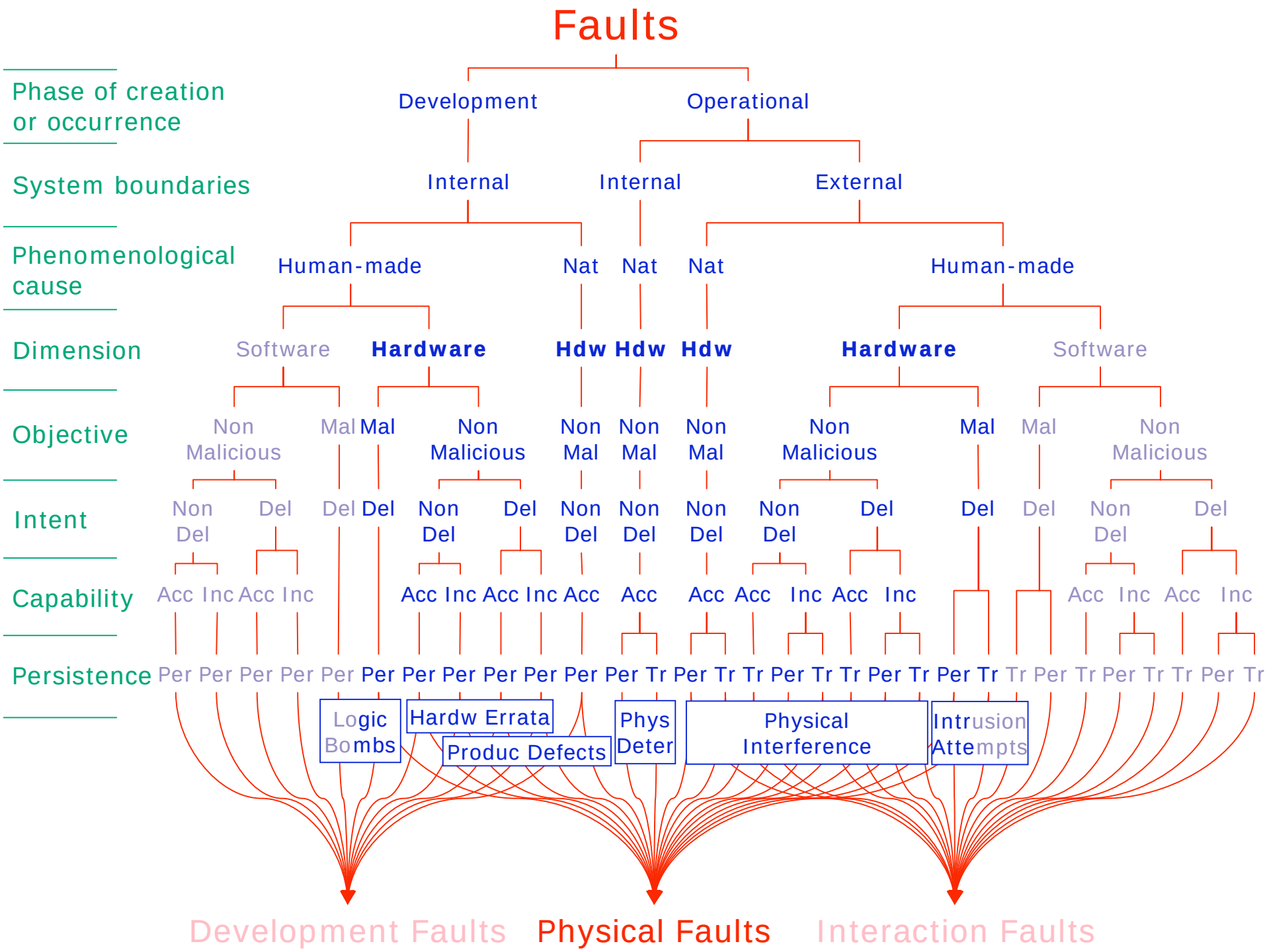
Software Flaws
Logic Bombs
Hardw Errata
Produc Defects
Development Faults
Physical Faults
Interaction Faults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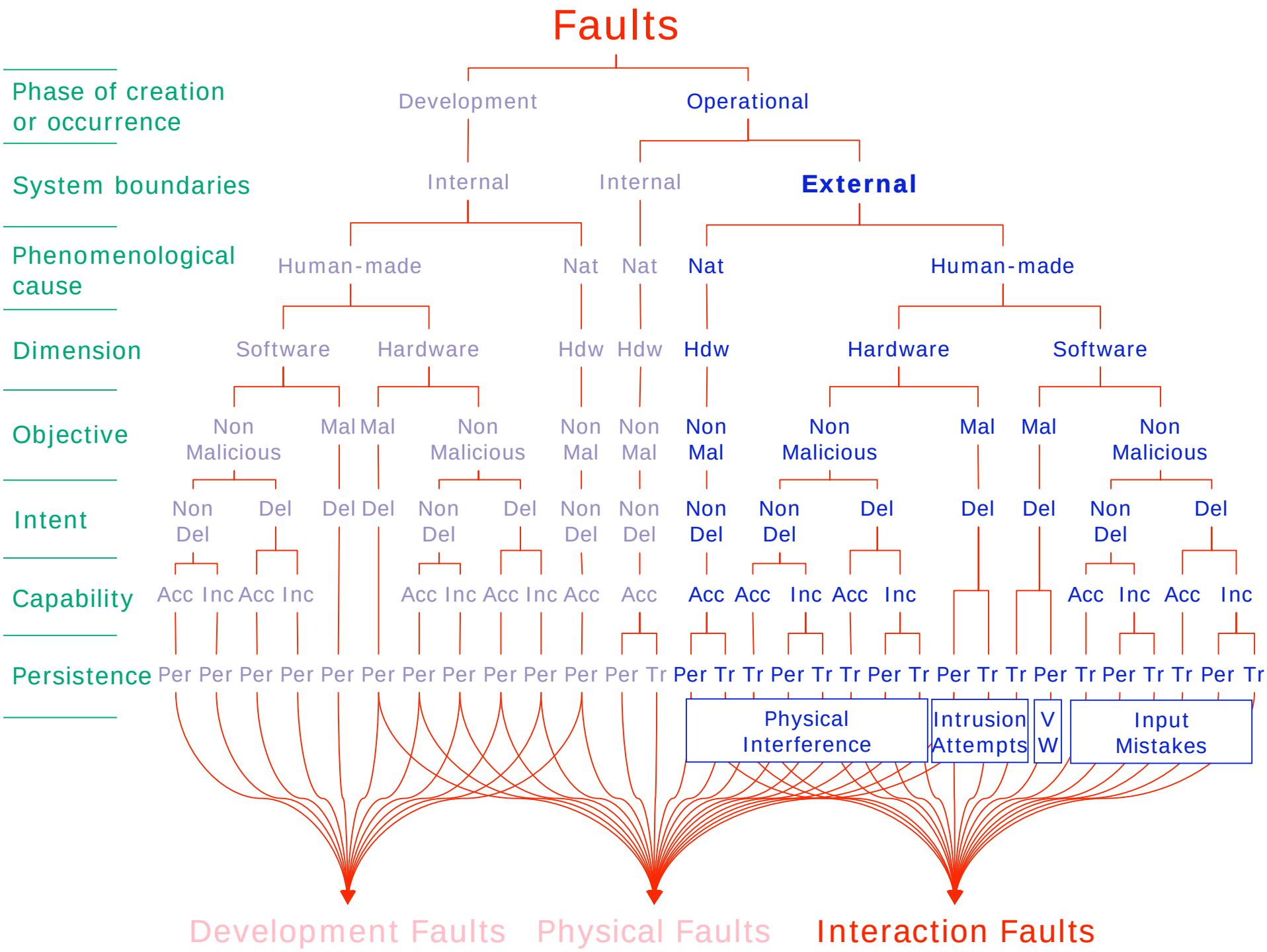
Logic Bombs
Hardw Errata
Produc Defects
Phys Deter
Physical Interference
Intrusion Attempts
Development Faults
Physical Faults
Interaction Faults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Physical Interference
Intrusion Attempts
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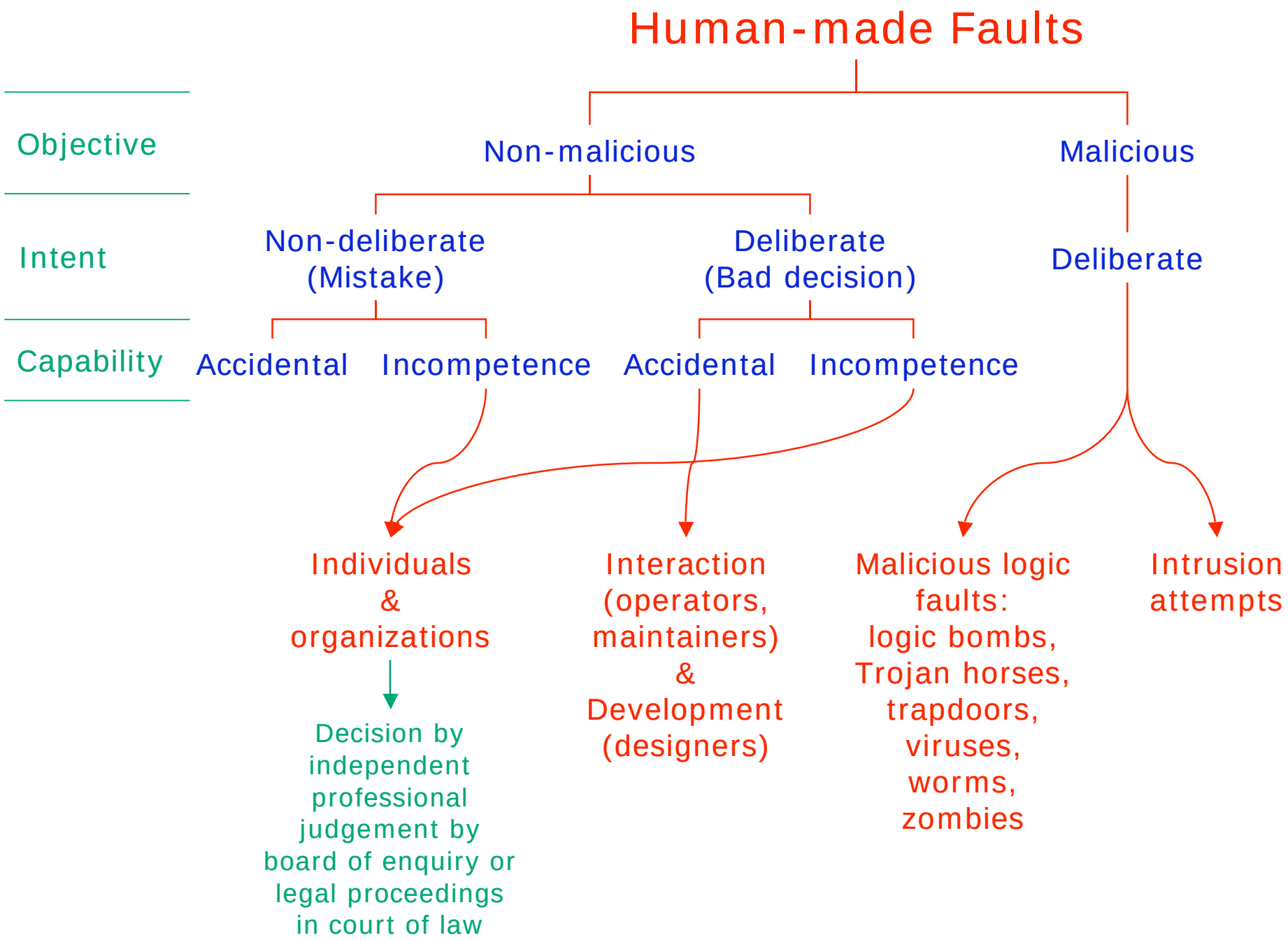
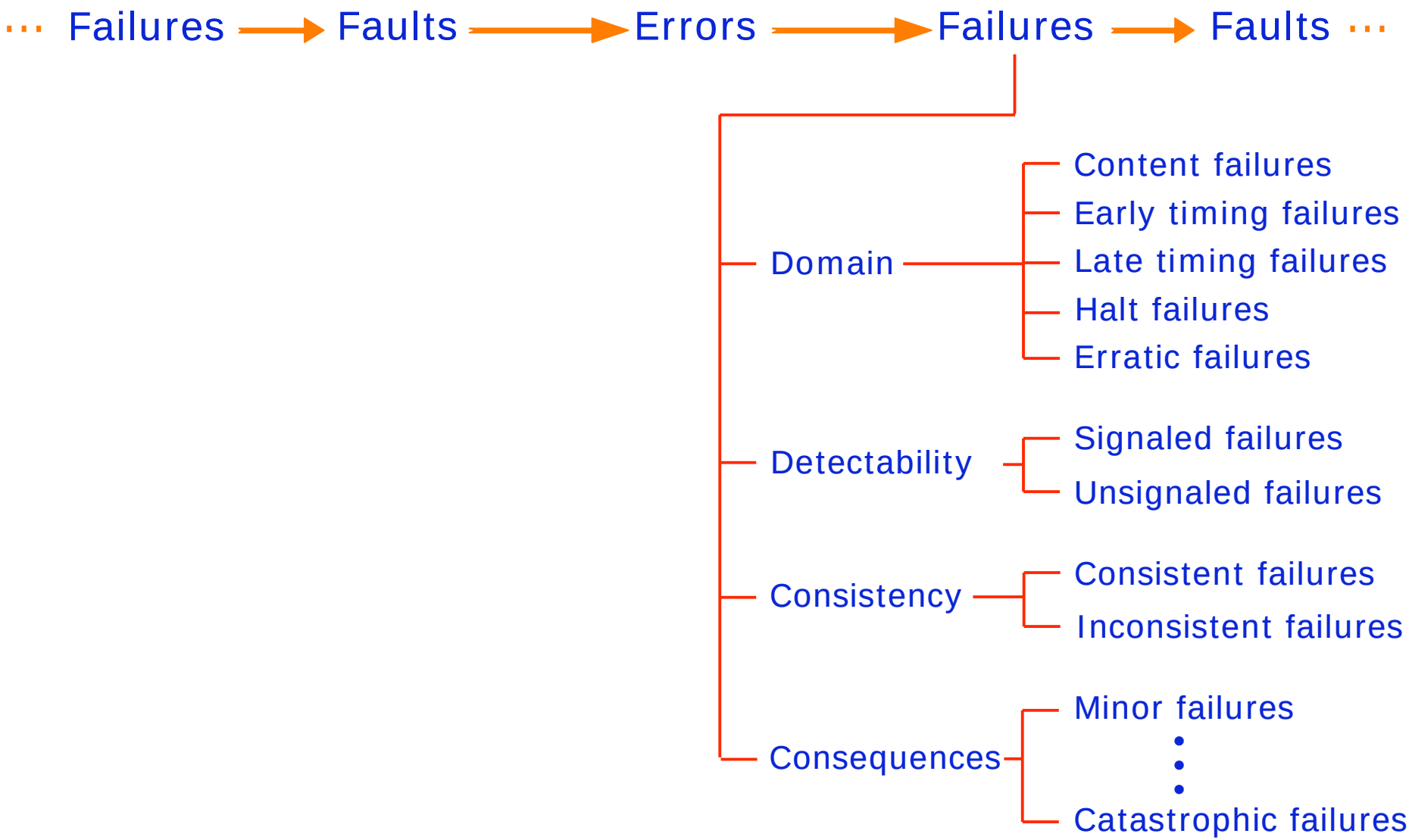
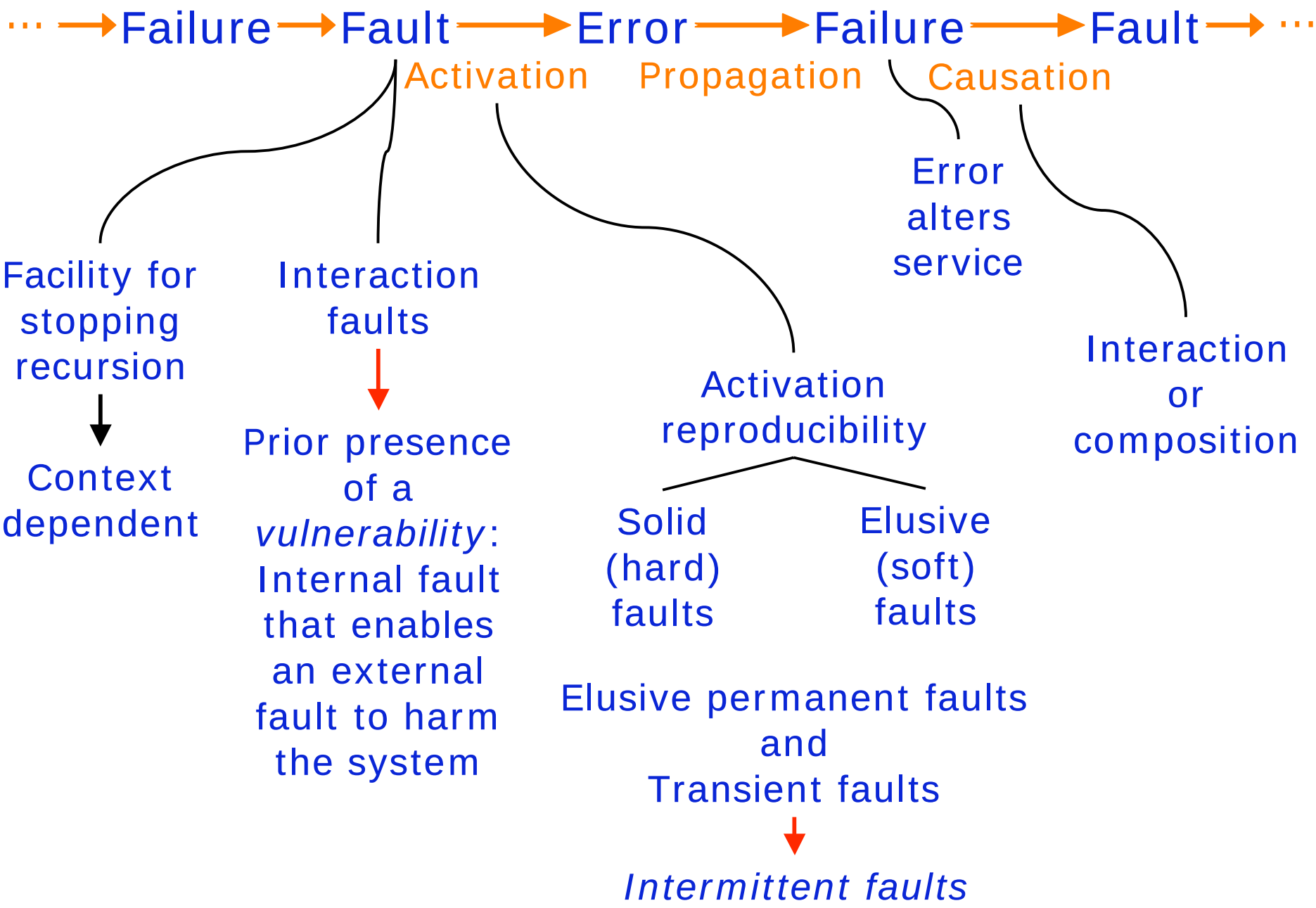
Input Mistakes
Development Faults
Physical Faults
Interaction Faults


Human-made Faults
Objective
Intent
Capability
Non-malicious
Malicious
Non-deliberate
(Mistake)
Deliberate
(Bad decision)
Deliberate
Accidental
Incompetence
Accidental
Incompetence
Individuals
&
organizations
Decision by
independent
professional
judgement by
board of enquiry or
legal proceedings
in court of law
Interaction
(operators,
maintainers)
&
Development
(designers)
Malicious logic
faults:
logic bombs,
Trojan horses,
trapdoors,
viruses,
worms,
zombies
Intrusion
attempts

Service Threats




… → Failure → Fault → Error → Failure → Fault → …
Activation
Propagation
Causation
Facility for stopping recursion
Context dependent
Interaction faults
Prior presence of a *vulnerability*: Internal fault that enables an external fault to harm the system
Activation reproducibility
Solid (hard) faults
Elusive (soft) faults
Elusive permanent faults and Transient faults
Intermittent faults
Error alters service
Interaction or composition

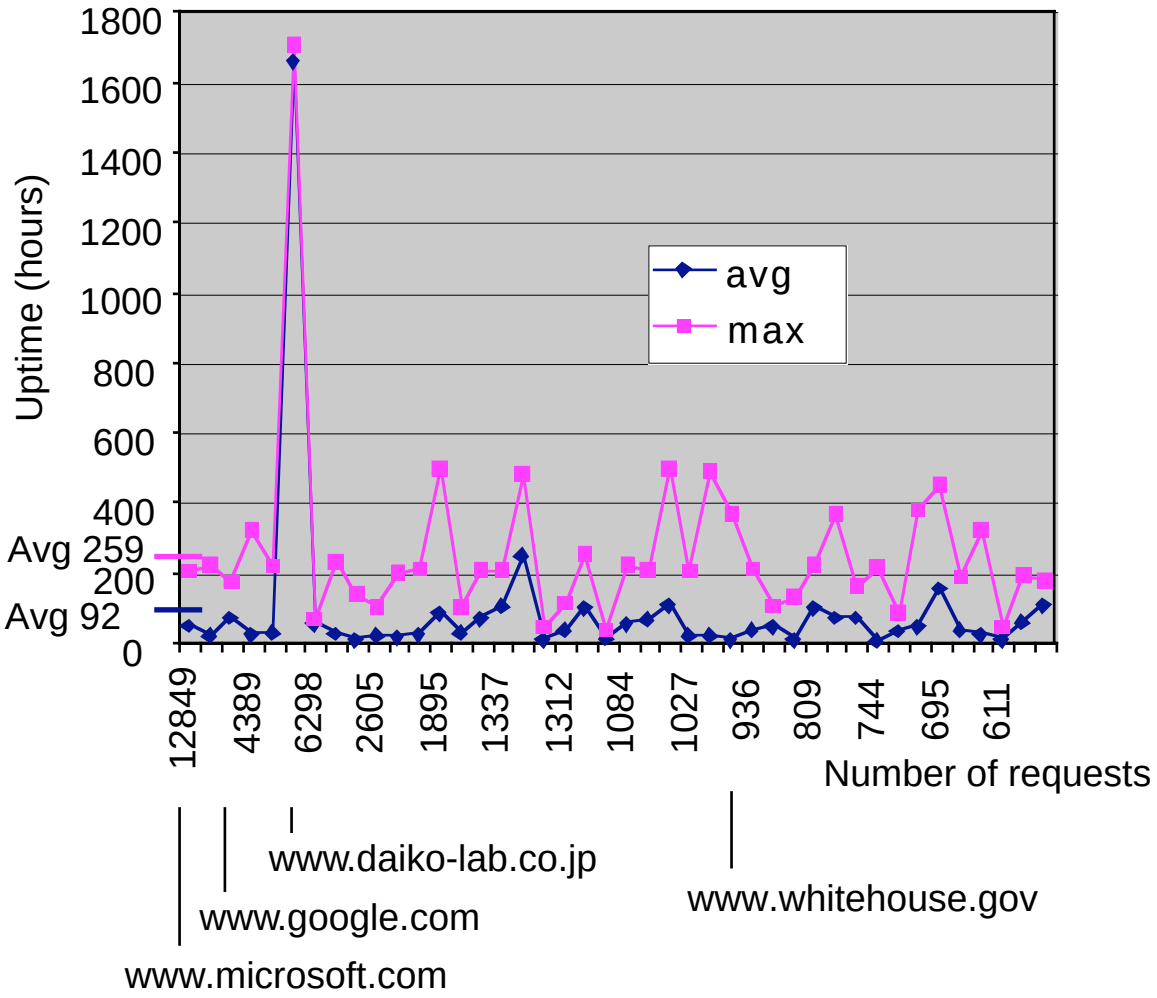
Non-malicious faults

Number of failures [consequences and outage durations highly application-dependent]	Computer systems (e.g., Transactions, Electronic switching, Back-end servers)		Larger, controlled systems (e.g., Commercial airplanes; telephone network; web applications)	
Faults	Rank	Proportion	Rank	Proportion
Physical internal	3	~ 10%	2	15-20%
Physical interaction	3	~ 10%	2	15-20%
Human-made interaction *	2	~ 20%	1	40-50%
Development	1	~ 60%	2	15-20%

* Root analysis evidences that they often can be traced to development faults

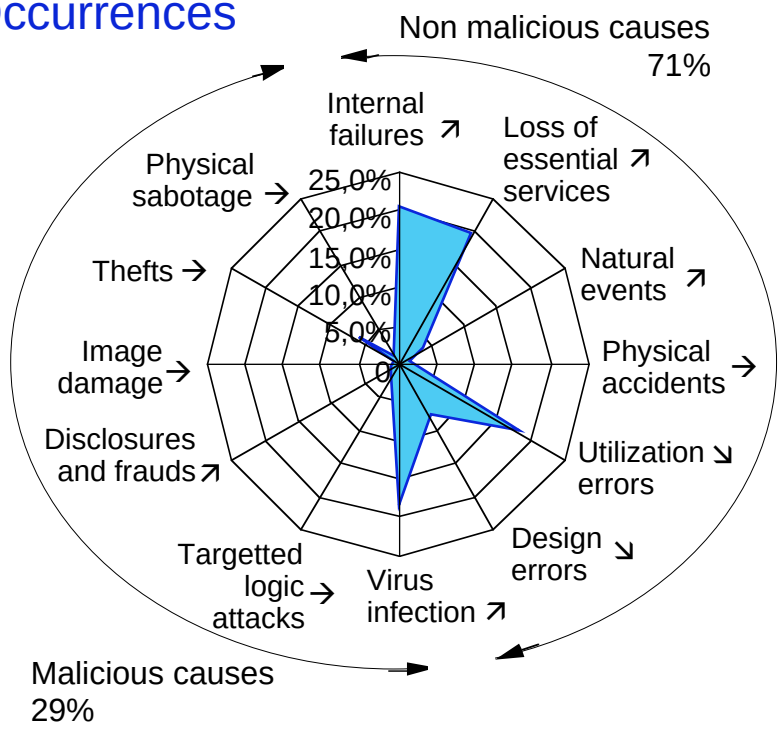
NetCraft — Uptime statistics (Dec 1, 2003)

Top 50 most requested sites

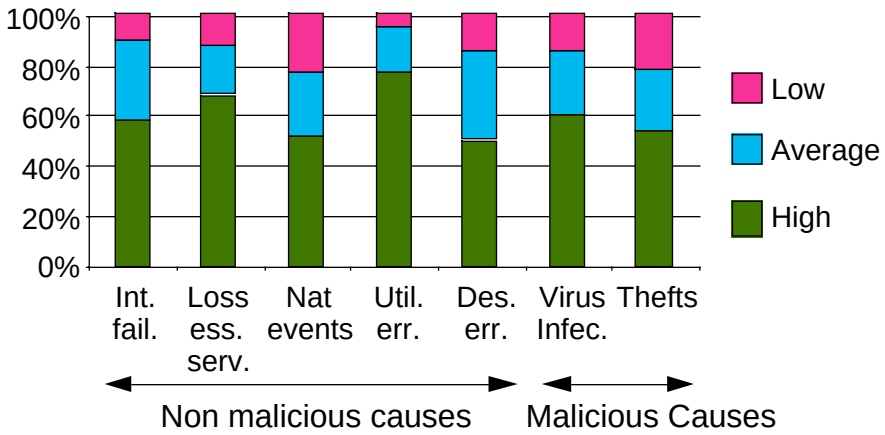


Yearly survey on computer damages in France — CLUSIF (2000, 2001, 2002)

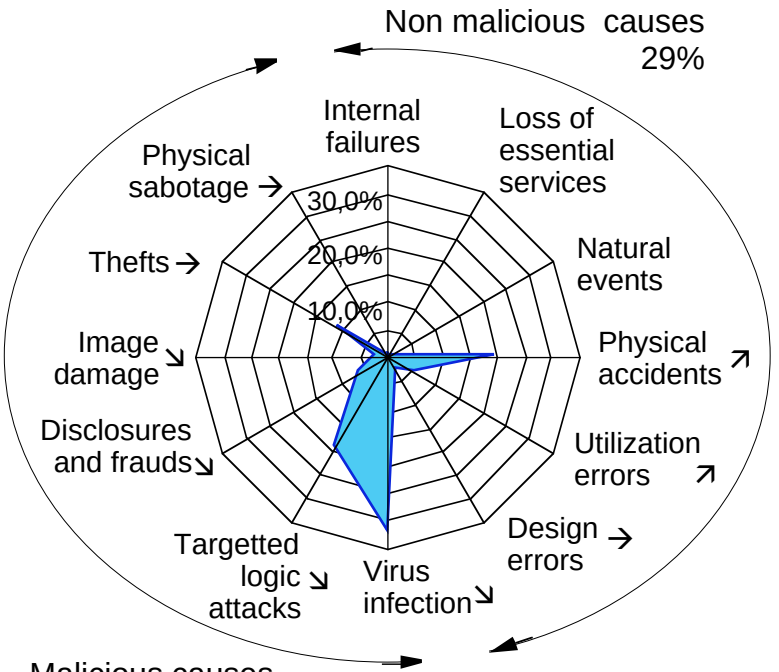
Occurrences



Occurrence impact



Risk perception



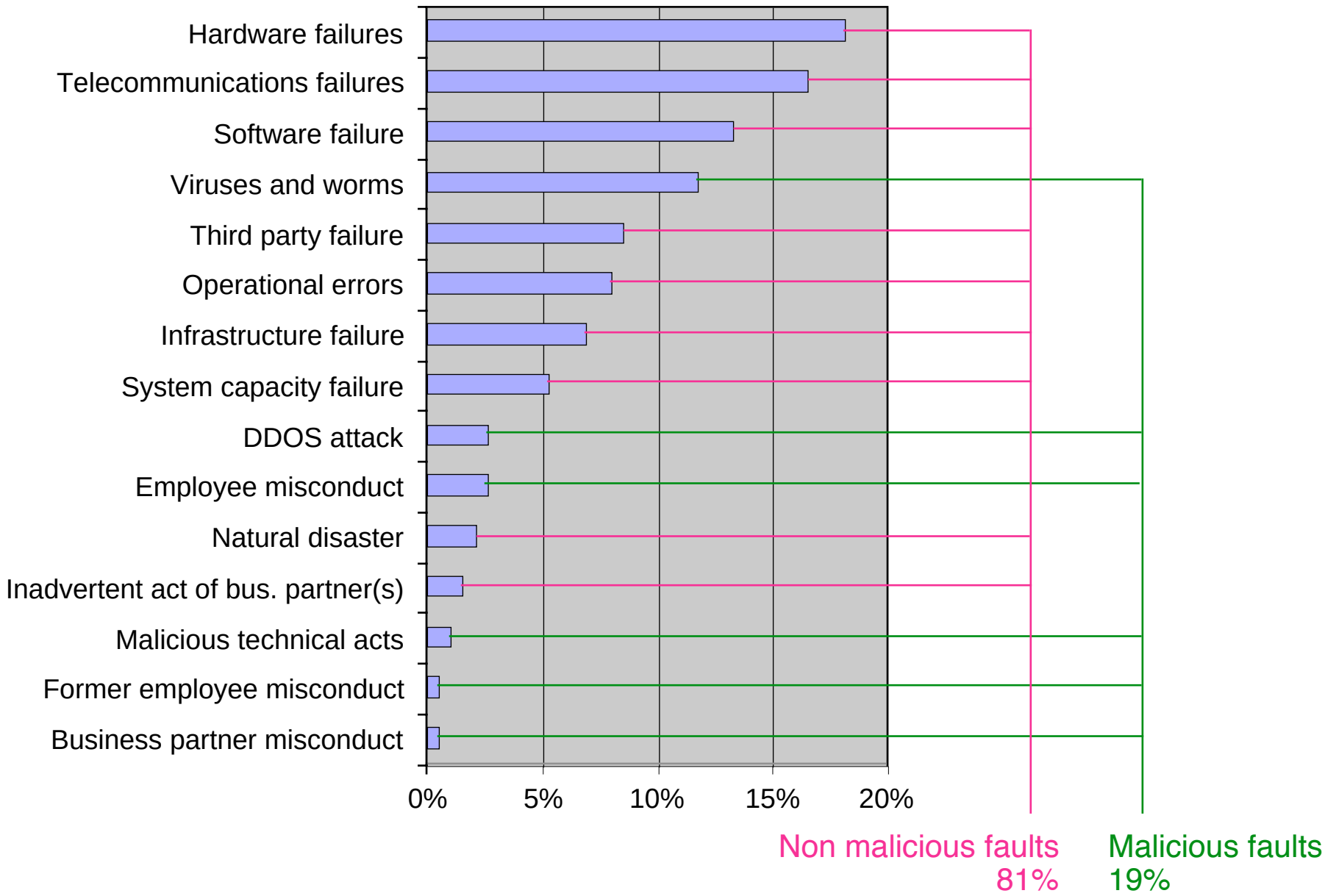
3 year trends

→ stable

↗ increase

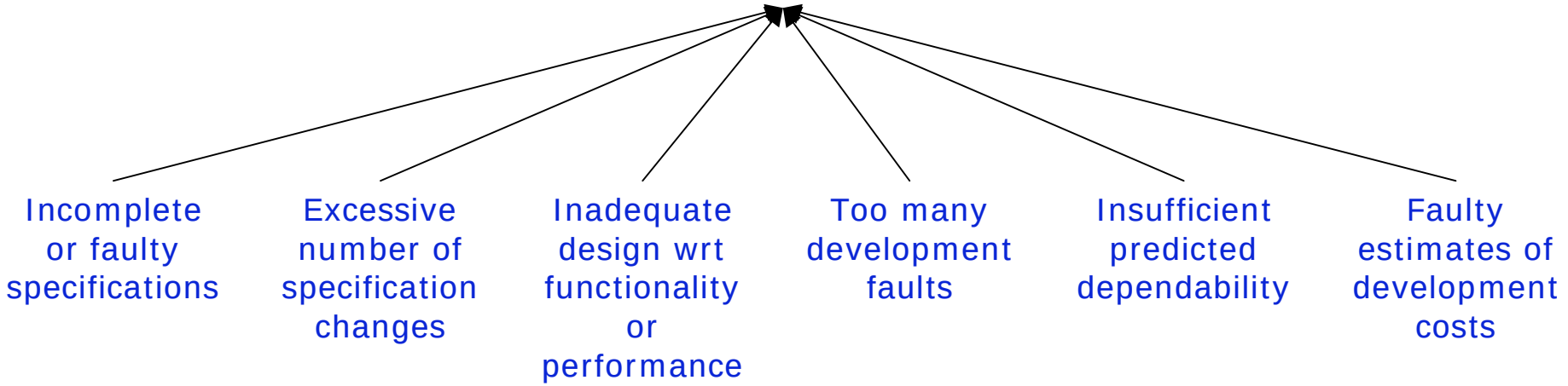
↘ decrease

Global Information Security Survey 2003 — Ernst & Young



Development failures

Development process terminates before the system is accepted for use and placed into service



Partial development failures

- Budget or schedule overruns
- Downgrading to less functionality, performance, dependability

Standish Group (*Chaos reports*)

	1994	2002
Number of surveyed projects	8,380	13,522
Successful projects (completed on-time and on-budget, with all features and functions as initially specified)	16%	34%
Challenged projects (completed and operational but over-budget, over the time estimate, and offers fewer features and functions than originally specified)	53%	51%
Canceled projects	31%	15%
Overruns for challenged projects	89%	82%
Left functions for challenged projects	61%	52%
Total estimated budget for software projects in the USA, in G$	250	225
Estimated lost value for software projects in the USA, in G$	81	38

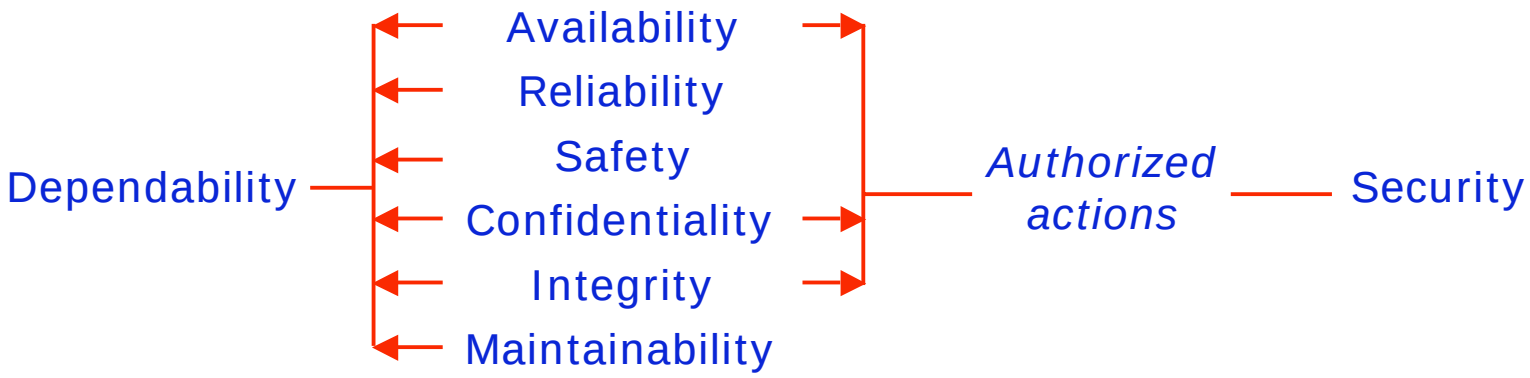
Dependability and its attributes

- Definitions of dependability
  - Original definition: ability to deliver service that can justifiably be trusted
    - Aimed at generalizing availability, reliability, safety, confidentiality, integrity, maintainability, that are then attributes of dependability
  - Alternate definition: ability to avoid service failures that are more frequent or more severe than is acceptable
    - A system can, and usually does, fail. Is it however still dependable ? When does it become undependable ?

      ⇓

      criterion for deciding whether or not, in spite of service failures, a system is still to be regarded as dependable.

- Dependability and security



- Dependence and trust
  - Dependence of system A on system B is the extent to which system A's dependability is (or would be) affected by that of system B
  - Trust: accepted dependence

Concept	Dependability	High Confidence	Survivability	Trustworthiness
Goal	1) ability to deliver service that can justifiably be trusted 2) ability of a system to avoid service failures that are more frequent or more severe than is acceptable	consequences of the system behavior are well understood and predictable	capability of a system to fulfill its mission in a timely manner	assurance that a system will perform as expected
Threats present	1) development faults (e.g., software flaws, hardware errata, malicious logic) 2) physical faults (e.g., production defects, physical deterioration) 3) interaction faults (e.g., physical interference, input mistakes, attacks, including viruses, worms, intrusions)	• internal and external threats • naturally occurring hazards and malicious attacks from a sophisticated and well-funded adversary	1) attacks (e.g., intrusions, probes, denials of service) 2) failures (internally generated events due to, e.g., software design errors, hardware degradation, human errors, corrupted data) 3) accidents (externally generated events such as natural disasters)	1) hostile attacks (from hackers or insiders) 2) environmental disruptions (accidental disruptions, either man-made or natural) 3) human and operator errors (e.g., software flaws, mistakes by human operators)

Conclusion

- Further discussion
  - Confidentiality
  - Trust and risk management
  - Human-machine interactions
  - Unified measures of dependability wrt non malicious and malicious faults

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  - New technologies, such as emerging from bio-info-nano convergence