Dependability and Security

Modelling, Metrics and Evaluation

Presented by

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OUTLINE OF LECTURE.

- Dependability and its attributes
- Security (and its aspects)
- An integrated system model
- A biological analogy
- Security (and Dependability) metrics
  - Evaluation according to the Common Criteria
- The time aspect
- Conclusions

GOAL OF LECTURE.

The goal of this lecture is to:

- answer the question: "What ***is*** SECURITY?"
- present a conceptual modelling of dependability and security, which should entail a new terminology or changed interpretation of the terminology.
  Thus, dependability and security represent different aspects of a common meta-concept.
- clarify security is multi-faceted and can not be treated as a clear-cut atomic concept.
- based on the conceptual model, suggest a structured way to measure security/dependability

DEPENDABILITY and its attributes

DEPENDABILITY ATTRIBUTES

Relation to the Dependability area:

DEPENDABILITY
ATTRIBUTES

Reliability Availability Safety Maintainability Confidentiality Integrity

WHAT IS DEPENDABILITY

DEPENDABILITY

- is a general, "umbrella" concept
- is not mathematically well-defined
- denotes the research area:
  Dependable Computing

DEFINITION OF RELIABILITY

- RELIABILITY *("continuity of service")*

The reliability R(t) of a system SYS can be expressed as:
R(t) = Prob (SYS is fully functioning in [0,t])

A metric for reliability R(t) is MTTF, the Mean Time To Failure

MTTF = $\int_0^\infty R(t)dt = \frac{1}{\lambda}$, where λ is the constant failure rate. MTTF is normally expressed in *hours*

DEFINITION OF AVAILABILITY

- AVAILABILITY *("readiness for usage" - incorporates maintainability (repair))*

The availability A(t) of a system SYS can be expressed as:
A(t) = Prob (SYS is fully functioning at time t)

A metric for the average, steady-state availability is $A(\infty) = \frac{MTTF}{MTTF + MTTR}$, where

MTTR = $\frac{1}{\mu}$, where μ is the constant repair rate.

$A(\infty)$ is normally expressed in %.

DEFINITION OF SAFETY

- SAFETY *("avoidance of catastrophic consequences on the environment")*

The Safety S(t) of a system SYS can be expressed as:
S(t) = Prob (SYS is fully functioning or has failed in a manner that does cause no harm in [0,t])

A metric for safety S(t) is MTTCF, the Mean Time To Critical Failure, defined similarly to MTTF and normally expressed in *hours*.

DEFINITION OF SECURITY

- SECURITY *("prevention of unauthorized access and/or handling")*

A system is considered Secure if it is can protect itself against intrusions

There is no mathematical or formal definition of the Security of a system.

There are no real metrics for security. Instead, there are a number of informal and/or subjective assessments or rankings.

Security is normally defined by its three aspects: confidentiality, integrity and availability (the *"CIA"*)

SECURITY ASPECTS

ITSEC:

INFORMATION SECURITY

Confidentiality Sekretess	Integrity Integritet	Availability Tillgänglighet
prevention of the unauthorized disclosure of information	prevention of the unauthorized modification of information	prevention of the unauthorized withholding of information or resources

AN INTEGRATED SYSTEM MODEL

INTEGRATED SECURITY and DEPENDABILITY ATTRIBUTES

BEHAVIOURAL DEPENDABILITY ATTRIBUTES

Reliability **Availability** Safety Maintainability **Confidentiality** **Integrity**

"other" characteristic *protective characteristic*

AN INTERPRETATION OF TRADITIONAL DEFINITION OF SECURITY

Information security
Datasäkerhet

Confidentiality	*Integrity*	*Availability* ("CIA")
Sekretess	Integritet	Tillgänglighet
prevention of the ***unauthorized*** disclosure of information	prevention of the ***unauthorized*** modification of information	information must be available to the ***authorized*** user
NOT OUT	NOT IN	(IN) OUT

SECURITY ASPECTS vs OBJECT SYSTEM

PROTECTIVE CHARACTE-RISTICS *CORRECTNESS* *BEHAVIOURAL CHARACTE-RISTICS*

ACCESSABILITY w.r.t ***the user***

INTEGRITY w.rt to the ***unauthorized user***

OBJECT SYSTEM

vulnerability svaghet

AVAILABILITY towards ***the user***

CONFIDENTIALITY towards the ***unauthorized user***

threat **attack** **intrusion** **erroneous state** **failure**

environmental **influence** system **function** **service** delivery

DEPENDABILITY ATTRIBUTES vs OBJECT SYSTEM

PROTECTIVE CHARACTE-RISTICS *CORRECTNESS* *BEHAVIOURAL CHARACTE-RISTICS*

ACCESSABILITY w.r.t ***the user***

INTEGRITY w.rt to the ***unauthorized user***

OBJECT SYSTEM

vulnerability svaghet feltillstånd **error**

RELIABILITY
AVAILABILITY
CORRECTNESS towards ***the user***

CONFIDENTIALITY towards the ***unauthorized user***

SAFETY

threat **attack** **intrusion** **erroneous state** **failure**

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A FUNDAMENTAL SYSTEM MODEL FOR DEPENDABILITY/SECURITY

<----------INTRUSION DETECTION ------------>

THREAT REDUCTION **BOUNDARY PROTECTION** **RECOVERY**

PROTECTIVE CHARACTE-RISTICS *CORRECTNESS* *BEHAVIOURAL CHARACTE-RISTICS*

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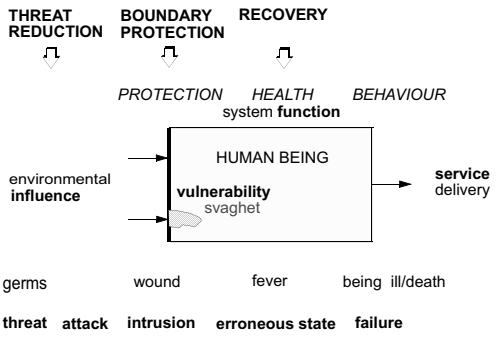
EXEMPLES of PROTECTION MECHANISMS - IN PRINCIPLE

- ***preventive protection - threat reduction:***
  - legal protection
  - reducing threats (e.g. "security check-ups")
  - **education / information / propaganda!**
- ***boundary protection:***
  - shield cables
  - encryption
  - physical protection (e.g. locks)
  - access control
- ***internal protection - recovery:***
  - (anti-)virusprograms
  - supervision mechanisms (with recovery capabilities)
  - encryption of stored data

A BIOLOGICAL ANALOGY

AN ANALOGY TO HUMAN BEINGS



SOME OBSERVATIONS FROM THE BIOLOGICAL ANALOGY

- **THREATS:**
  Threats are there all the time.
  Threats change and evolve.
- **PROTECTION MECHANISMS:**
  Protection takes place at different levels.
  Protection mechanisms are active continuously.
  Protection mechanisms must also change and evolve according to the threats.
  Even anticipatory protection exists. (inoculation)

☞ **Hypothesis:**
Modern IT systems are so complicated so that a biological paradigm must be adapted. Thus, security protection must be a continouos process, taking place simultaneously on all protection levels. Security protection must be adaptive.

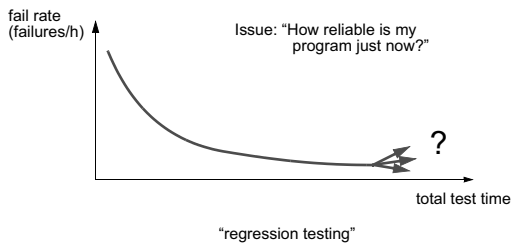
THE TIME ASPECT

THE TIME ASPECT - SOME OBSERVATIONS

- The time aspect is very often neglected in security analysis. It must be noted that:
- introduction of a fault into the system does not mean that the system fails immediately. It may never fail due to this fault. The **latency** aspect - fault propagation.
- the latency clearly affects metrics of system behaviour. There might be a substantial time between the original fault occurrence and the resulting (deficient) system behaviour.
- faults can be introduced into a system throughout its lifetime. Many faults are introduced during the design phase.
- Some security mechanisms does not protect the system as it stands. But it will give information for improving

THE TIME ASPECT - DEBUGGING (A software analogy)

"the law of diminishing results"
(regarding debugging of software):
It will be increasingly hard to find the remaining faults



"regression testing"

THE TIME ASPECT - LATENCY (Another software analogy)

- A program can have many errors with very long MTTF.
- An investigation of an IBM-program showed that more than 30% of the errors had an **MTTF > 5000 years!!** This means that if we test the system continuously, after 5000 years some 30 % of the errors remain latent!
  (Ref: E. N. Adams: "Optimizing preventive service of software products", *IBM Journal of Research and Development,* vol. 28, No. 1, pp. 2-14, 1984.)
- The same problem applies to *security vulnerabilities*

CONCLUSIONS (general):

- The areas of Dependability and Security have traditionally evolved separately and there is a lack of coordination between them regarding concepts, terms, tools etc
- Dependability and Security reflect two different approaches to the same fundamental research area
- Dependability and Security must be integrated into one common context in order for us to be able to properly address the problems involved

CONCLUSIONS (specific):

- We have suggested an ***integrated system model*** for Dependability and Security, describing the system in terms of ***correctness*** as well as ***protective*** and ***behavioural characteristics***
- Dependability and Security metrics can be defined in accordance
- Protection methods and mechanisms have been related to the system model
- Intrusion detection is a mechanisms that introduces the "product-in-a-process" concept for the system