# TOWARDS METRICS-DRIVEN ADAPTIVE SECURITY MANAGEMENT IN E-HEALTH IoT APPLICATIONS

Reijo M. Savola[1], Habtamu Abie[2], Markus Sihvonen[3]
[1] VTT Technical Research Centre of Finland, FI
[2] Norwegian Computing Center, NO
[2] Mikkelin Puhelin Oyj, FI

Teknologiasta liiketoimintaa

SeTTIT 2012
Oslo, Norway

# CONTENTS

- Introduction
- High-Level Security Objectives
- Proposed Adaptive Security Approach
- Conclusions and Future Work

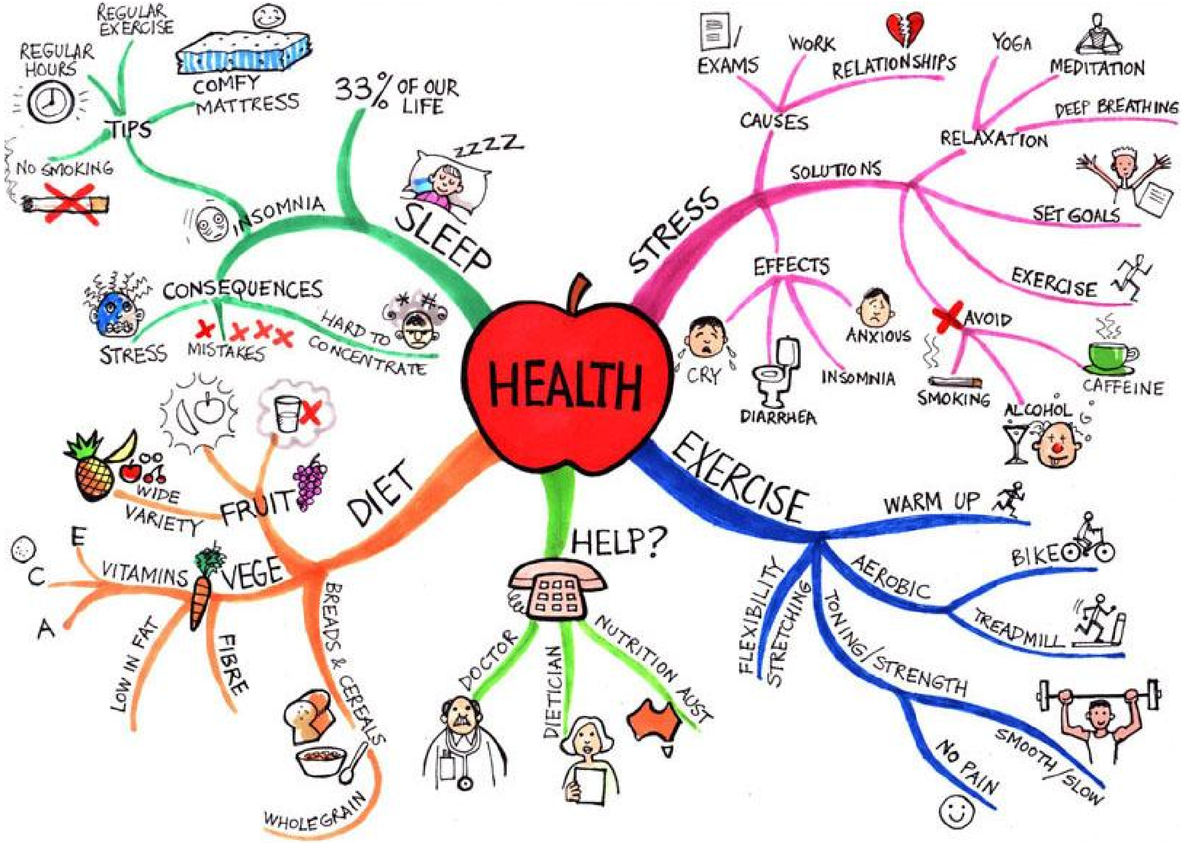
”An activity cannot be managed well if it cannot be measured.”

# INTRODUCTION
## Number of people with chronic diseases on the rise

- Diabetes: rising from 171 million (2000) > 366 million (2030) according to WHO
- COPD: (Chronic Obstructive Pulmonary Disease), rising, major cause of chronic morbidity and mortality worldwide
- Arthritis: rising

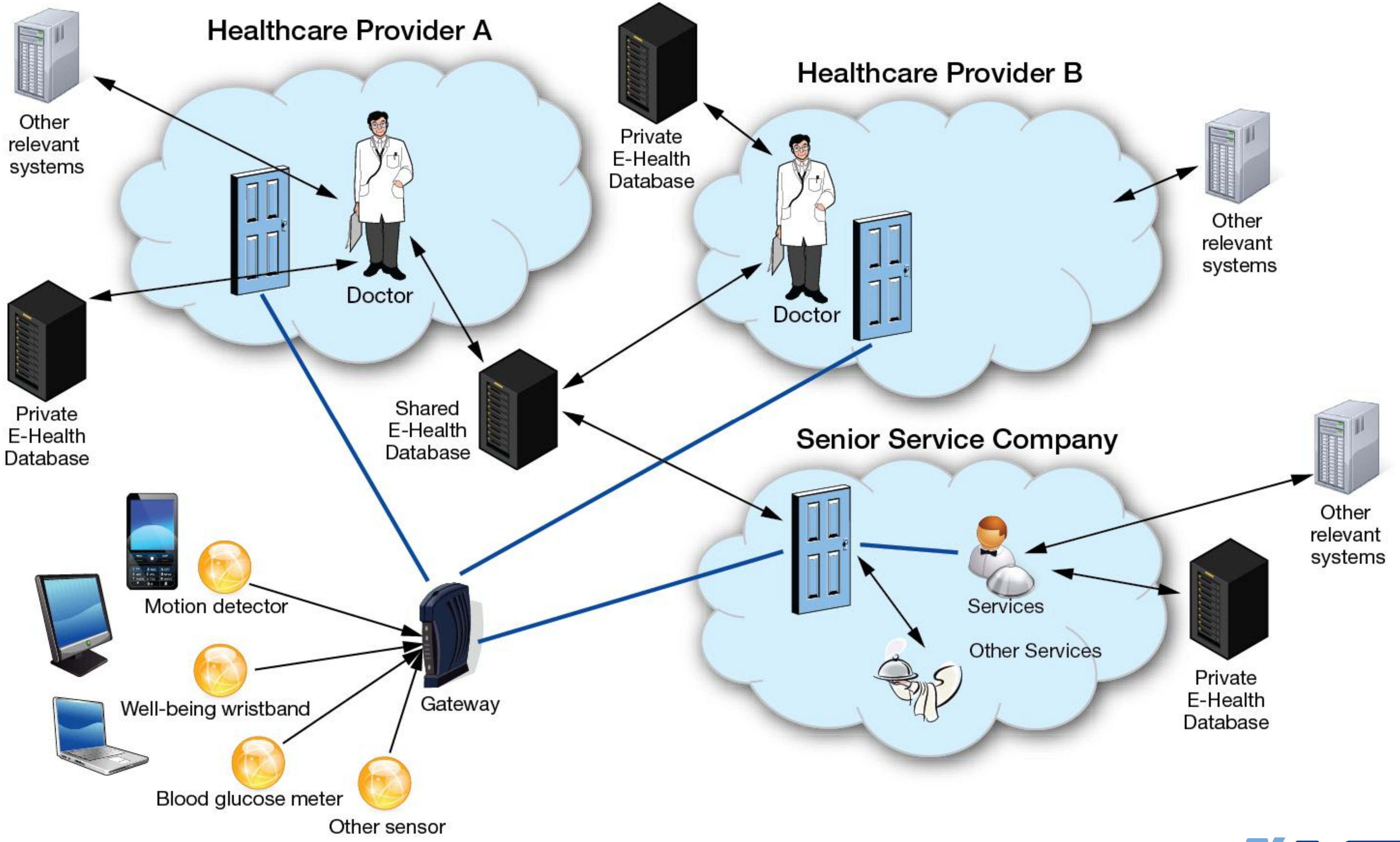
Immediate and effective preventive actions are needed to reserve the trend!

- Self-care support by technology is very promising direction!



*Learningfundamentals.com.au/resources/*

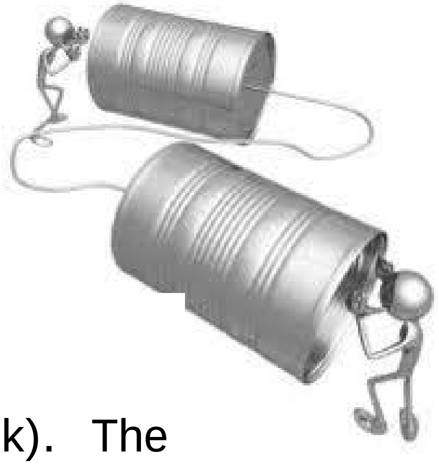
# INTRODUCTION
## Use of IoT technology in self-care



# INTRODUCTION
## Collaboration and adaptiveness in security/privacy

- Controlled collaboration and information sharing needed
  - Healthcare providers can change
  - People travel a lot
- Support for adaptiveness is crucial
  - Security and privacy risks change dynamically
  - Sufficient security and privacy level should be maintained during the changes

# INTRODUCTION
## Communication levels, security domains



*Lloyd Christten*

*Leister et al.:*

| CL | Description |
|---|---|
| 0 | Patient |
| 1 | Personal sensor network like BSN (Biomedical Sensor Network). The sensors form BSN. |
| IIa | Paramedic scenarios |
| IIb | Smart home scenarios. |
| IIc | Mobility scenarios. |
| IId | Intensive care or surgery. |
| IIe | Pre- or postoperative sensor data management |
| III | Healthcare information system comprising the hospital network, computing facilities, databases and access terminals in the hospital. |

*Proposal of additional levels:*

| | |
|---|---|
| IIIa | Utilization of BSN data by medical doctors and other healthcare personnel in non-emergency treatment of individual patient with a chronic disease. |
| IV | Information sharing between different healthcare providers concerning medical information of an individual patient. |
| V | Information sharing between healthcare providers and medical research organizations for the purposes of research, new solutions development and feedback to CL 0-IV. |

# HIGH-LEVEL SECURITY OBJECTIVES
# Authentication and authorization

High-level objectives

- End-user and sensor authentication: adequate authentication strength is a highly critical parameter in ensuring that the right person receives the right treatment
- Service provider user authentication and authorization: (1) take different privacy levels into account, (2) define pre-authorized roles to indicate the type of data that a person can access
- Usability of authentication mechanism(s) is emphasized especially for seniors.

Adaptivity need

- Support changing context of use, security threats, privacy rec and user behavior
- Setting requirements and enforcing mechanisms

*Rationalsecurity.typepad.com*

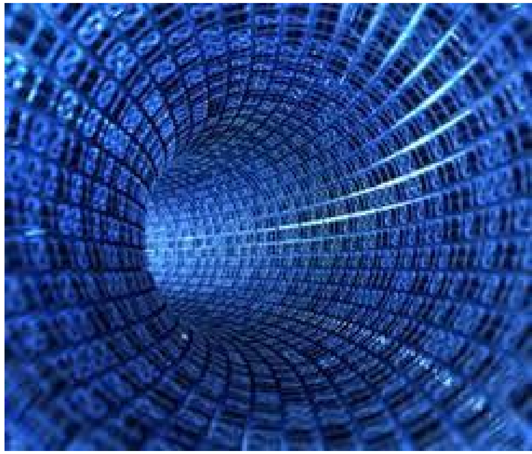
# HIGH-LEVEL SECURITY OBJECTIVES
## Data integrity

### High-level objectives

- Especially in paramedic situations, lost, delayed or altered data can cause direct damage to the patient’s health. Moreover, indirectly, data integrity is important to longer-time treatment decisions.

### Adaptivity need

- Carefully designed adaptation needed especially during alarm situations.



*Telefunken Racoms*

# HIGH-LEVEL SECURITY OBJECTIVES
## Privacy and confidentiality

### High-level objectives

- Privacy and confidentiality are very emphasized in healthcare information systems.
- Strong confidentiality algorithms, key management and associated processes are crucial.
- Compliance to privacy legislation and regulations are needed despite of varying use cases.

### Adaptivity need

- Adaptation to privacy and confidentiality requirements needs to take into account data processing needs, roles of stakeholders, regulations/legislation and privacy level information

*Discovery news*

# HIGH-LEVEL SECURITY OBJECTIVES
## Availability

### High-level objectives

•Availability of sensor data are important especially in paramedic and alarm situations.

•Availability of the service provider’s systems can be critical for health and life.

### Adaptivity need

•Adaptive techniques are needed to balance the load in the system and to use resilience solutions to maintain adequate availability.

*medGadget*

# HIGH-LEVEL SECURITY OBJECTIVES
## Non-repudiation

### High-level objectives

- Non-repudiation can be potentially a challenge especially in senior citizen care and in medical alarm situations.
- Sufficient non-repudiation solutions for these challenging situations are needed.

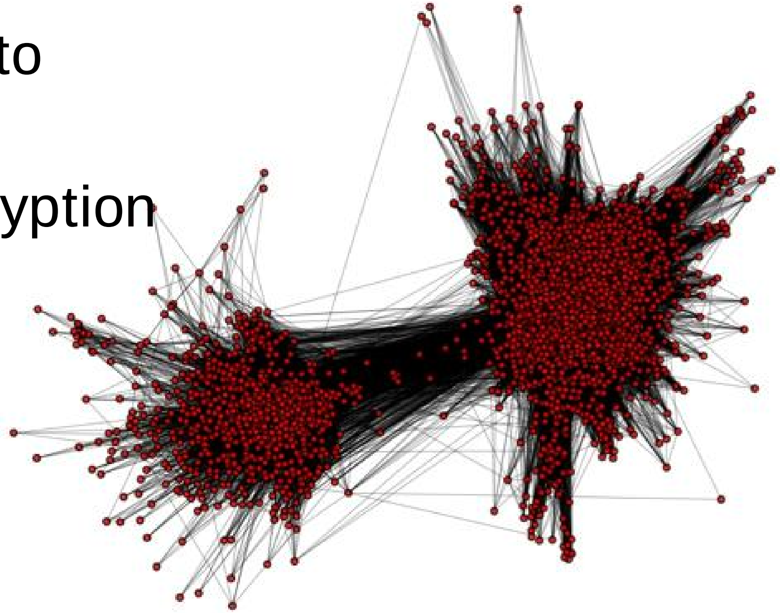
### Adaptivity need

- Adaptive techniques are needed to ensure the adequate non-repudiation level despite of changing conditions.

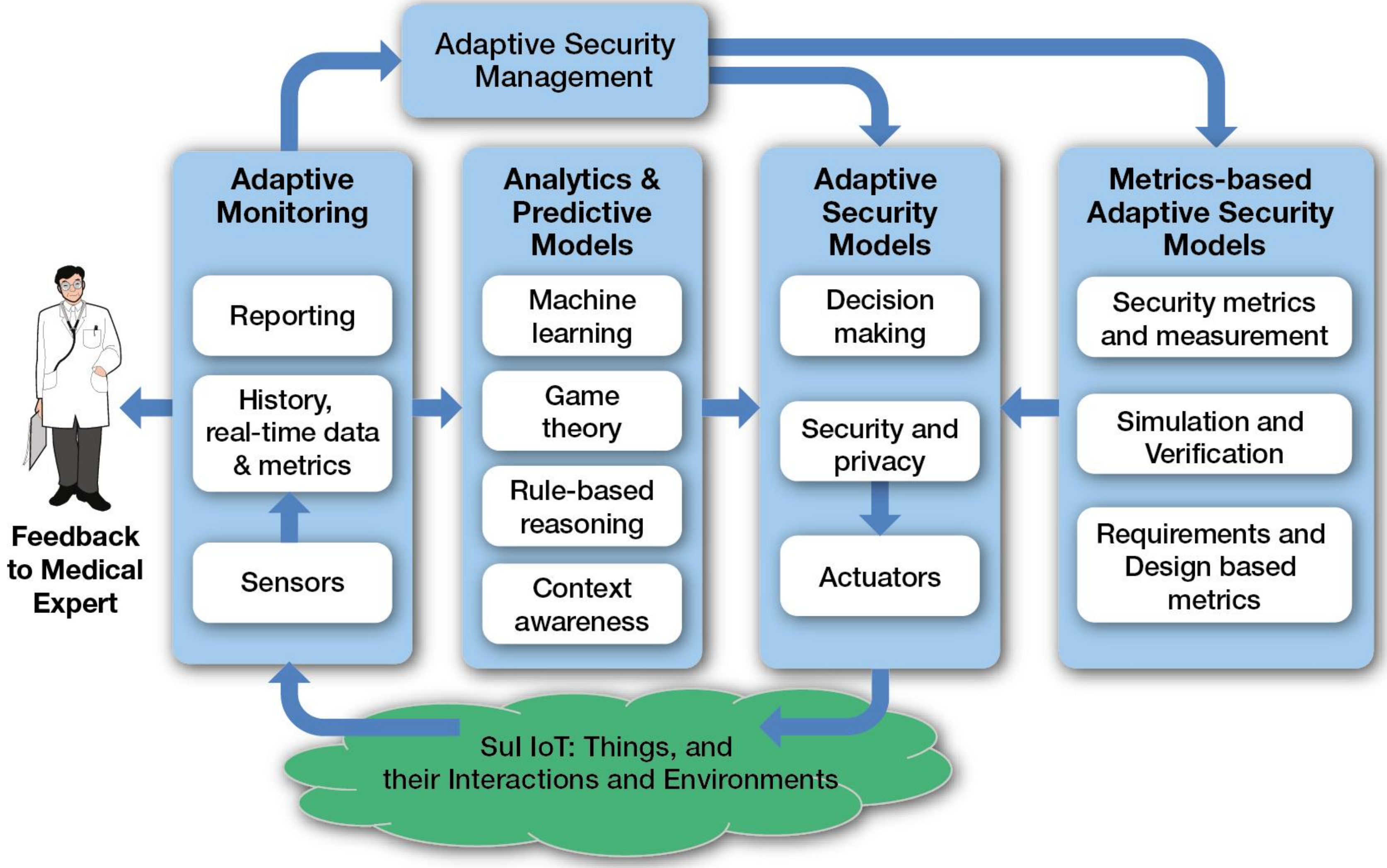
# PROPOSED ADAPTIVE SECURITY APPROACH
## Adaptive security management model

Adaptive security involves

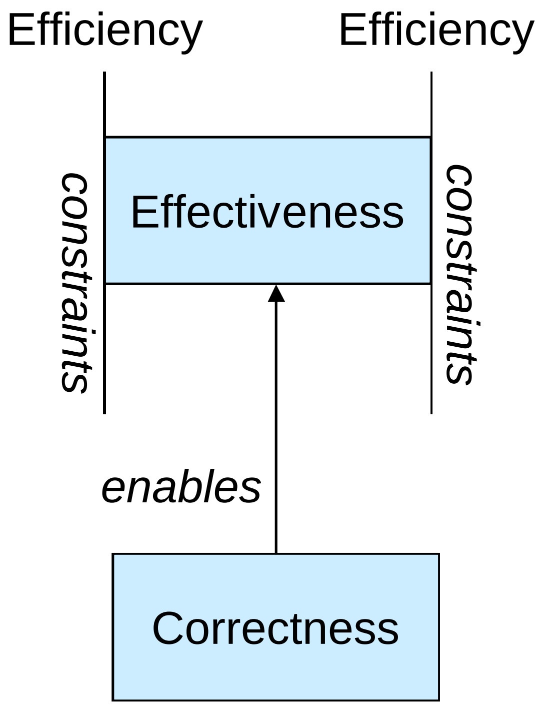
- Gathering contextual information,
- Measuring security level and metrics,
- Analyzing the collected information and responding to changes by:
  - Adjusting internal working parameters (like encryption schemes, security protocols, security policies, algorithms authentication and authorization mechanisms and QoS)
  - Making dynamic changes in the structure of the security system.



# PROPOSED ADAPTIVE SECURITY APPROACH
## Adaptive security management model


Adaptive Security Management
Adaptive Monitoring
Reporting
History, real-time data & metrics
Sensors
Analytics & Predictive Models
Machine learning
Game theory
Rule-based reasoning
Context awareness
Adaptive Security Models
Decision making
Security and privacy
Actuators
Metrics-based Adaptive Security Models
Security metrics and measurement
Simulation and Verification
Requirements and Design based metrics
Feedback to Medical Expert
SuI IoT: Things, and their Interactions and Environments

# PROPOSED ADAPTIVE SECURITY APPROACH
## Security metrics objectives



Efficiency

Efficiency

Effectiveness

constraints

constraints

enables

Correctness

- SECURITY CONTROL
- Security controls are means of managing privacy risk, which can be administrative, technical, management, or legal in nature (based on ISO/IEC 27000's security control concept)
- SECURITY CONTROL CORRECTNESS
- Security correctness denotes assurance that privacy controls have been rightly implemented in the SuI, and the system, its components, interfaces and the processed data meet privacy requirements.
- SECURITY CONTROL EFFECTIVENESS

THE MAIN OBJECTIVE!

- Security effectiveness denotes assurance that stated privacy objectives are met in the SuI and expectations for resiliency in the use environment are satisfied, while the SuI does not behave in any other way than what is intended.
- SECURITY CONTROL EFFICIENCY
- Security efficiency denotes assurance that the adequate privacy quality has been achieved in the SuI meeting resource, time and cost constraints.

# PROPOSED ADAPTIVE SECURITY APPROACH
## Risk-driven = Top-down metrics development

(1) Identify successive components from each security requirement

(2) Examine the subordinate nodes to see if further decomposition is needed. If so, repeat (1) and (2).

(3) Terminate the decomposition when none of the leaf nodes can be decomposed any further.

E.g. authentication:

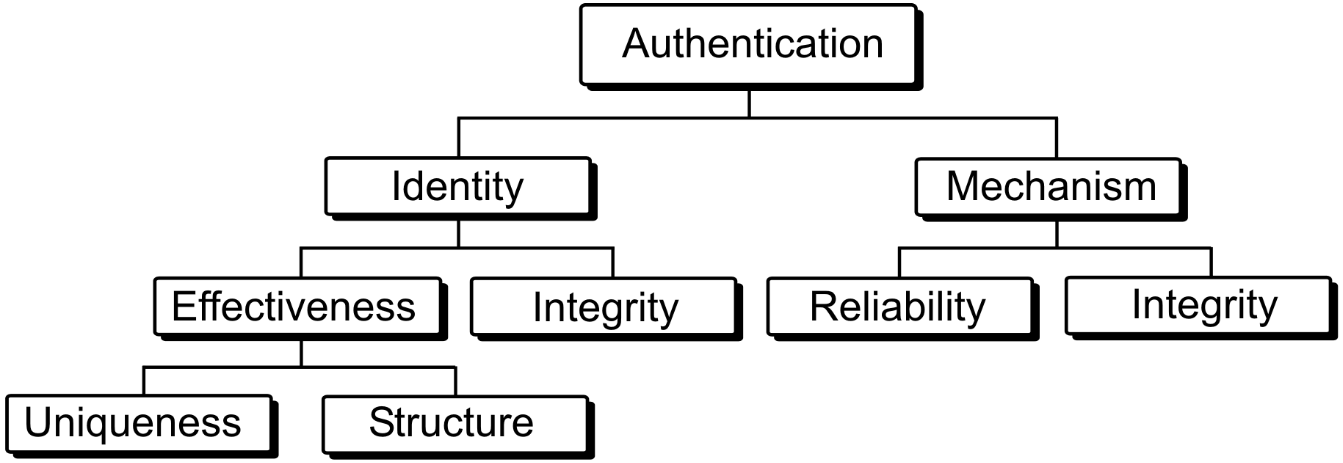
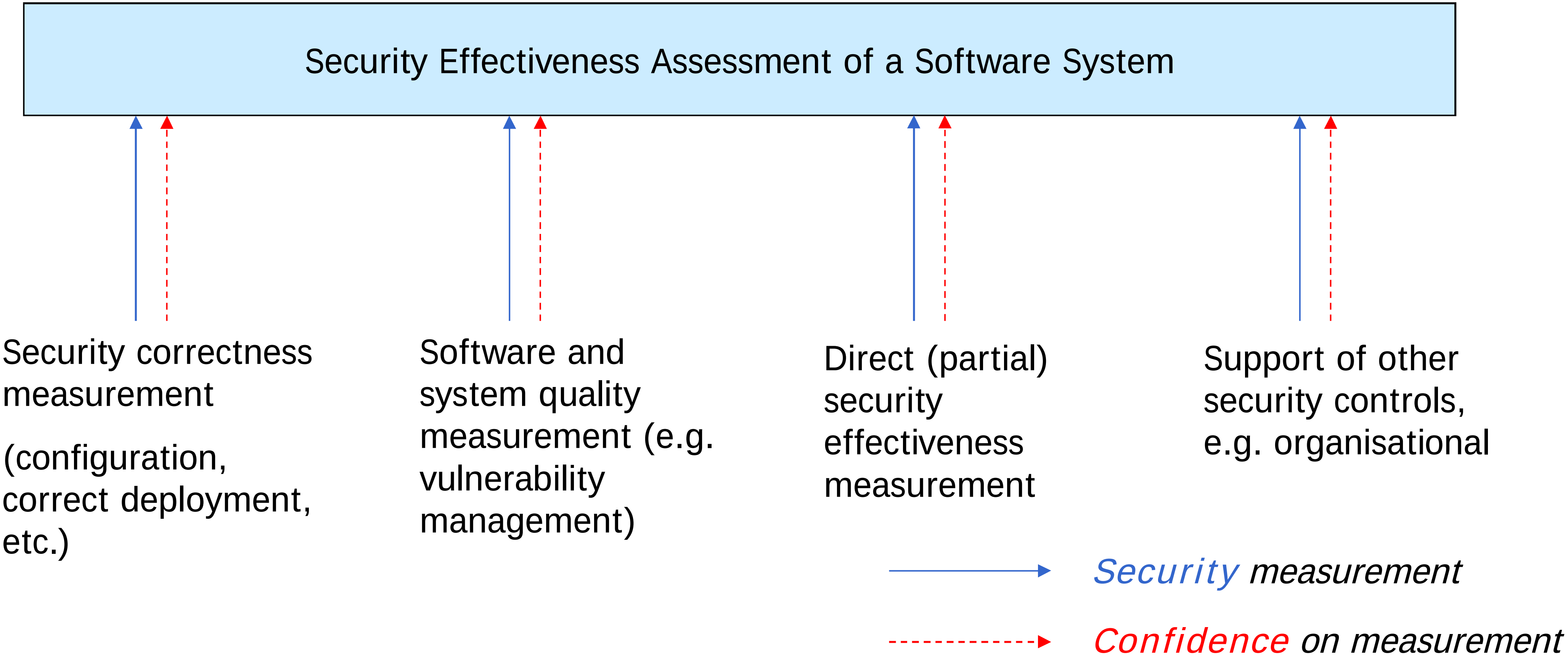


*Figure: Savola, R. & Abie, H. Development of Measurable Security for a Distributed Messaging System. Int. Jnl on Advances in Security, Vol 2 No 4, 2009.*

In practice: The same example is >100 detailed metrics

# PROPOSED ADAPTIVE SECURITY APPROACH
## Factors contributing to security effectiveness



Security Effectiveness Assessment of a Software System

Security correctness measurement

(configuration, correct deployment, etc.)

Software and system quality measurement (e.g. vulnerability management)

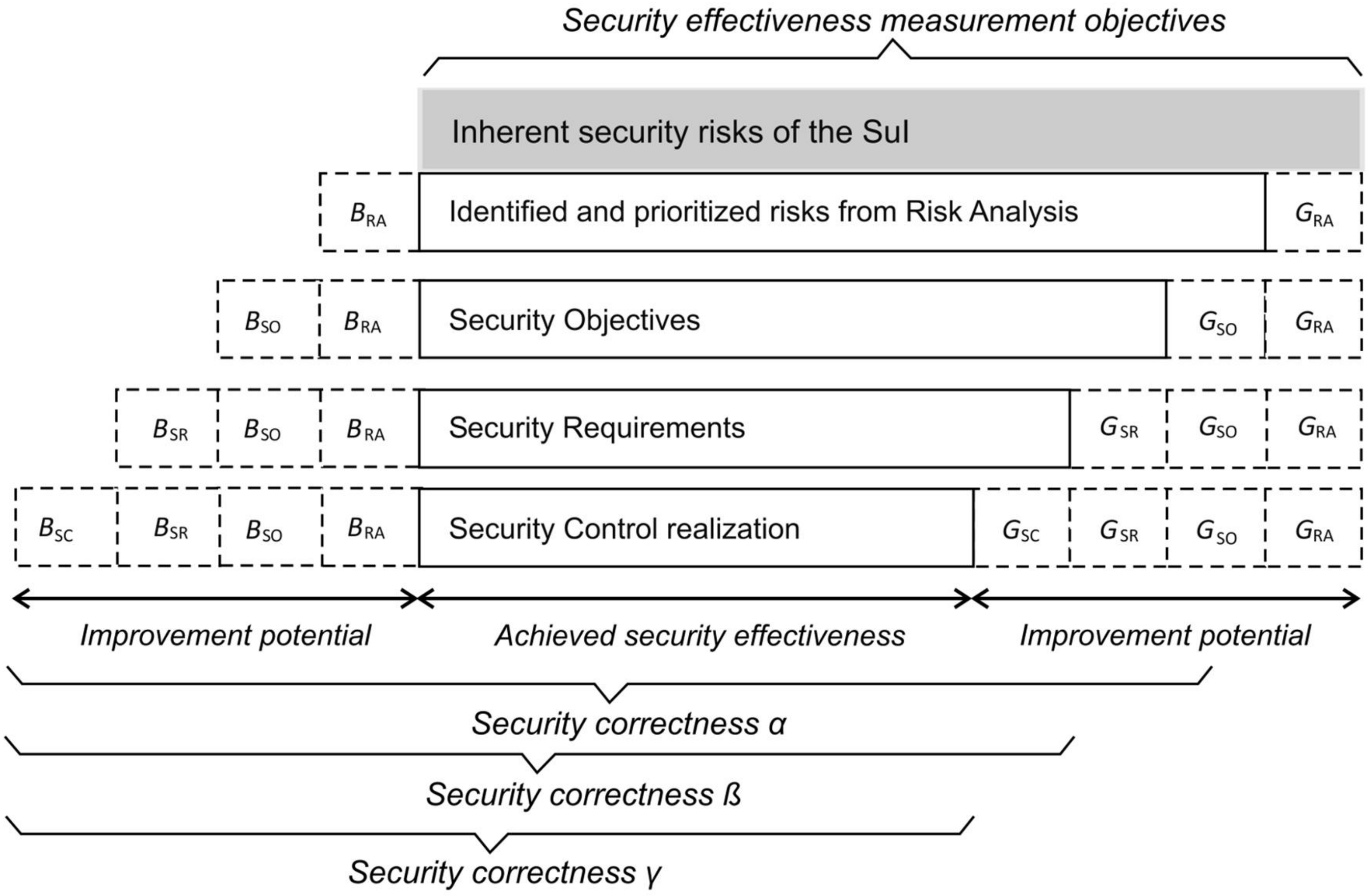
Direct (partial) security effectiveness measurement

Support of other security controls, e.g. organisational

*Security measurement*

*Confidence on measurement*

# PROPOSED ADAPTIVE SECURITY APPROACH
## Gaps and biases – metrics can help!



*Security effectiveness measurement objectives*

Inherent security risks of the SuI

$B_{RA}$ Identified and prioritized risks from Risk Analysis $G_{RA}$

$B_{SO}$ $B_{RA}$ Security Objectives $G_{SO}$ $G_{RA}$

$B_{SR}$ $B_{SO}$ $B_{RA}$ Security Requirements $G_{SR}$ $G_{SO}$ $G_{RA}$

$B_{SC}$ $B_{SR}$ $B_{SO}$ $B_{RA}$ Security Control realization $G_{SC}$ $G_{SR}$ $G_{SO}$ $G_{RA}$

*Improvement potential* *Achieved security effectiveness* *Improvement potential*

*Security correctness α*

*Security correctness ß*

*Security correctness γ*

*Figure: Savola, R., Frühwirth, C., Pietikäinen A., ”Risk-driven security metrics in agile software development – an industrial pilot study”. Accepted to Journal of Universal Computer Science, 2012.*

# CONCLUSIONS AND FUTURE WORK

- Security objectives of e-health IoT scenarios are specific
  - Need to share information
  - High privacy regulation
  - Paramedic and alarm situation are a challenge
  - Usability is a challenge
- Adaptive security management is needed for
  - Setting the sufficient security requirements
  - Enforcing the adequate security controls in the face of changing security risks and use context
- Informed adaptive security decision-making is based on adequate security metrics
- Future work: (1) detailed analysis and specification of security metrics and adaptive decision-making algorithm, (2) experimentation system

TiViT | INTERNET OF THINGS

ADAPTIVE SECURITY FOR SMART INTERNET OF THINGS IN EHEALTH

ASSET

# Thank you!
# Questions?