# SECURITY REQUIREMENTS IN STSs

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# OUTLINE

- What are STSs
- Linking security requirements in STSs
- Checking alignment of security requirements
- Conclusion

# SOCIO-TECHNICAL SYSTEMS (STSs)

- STS are **information systems** where **human and technical components interact** to each others so to achieve common objectives.
- Examples:
  - Health Care System (HCS)
  - Smart cities
  - Smart houses
  - Air traffic management
  - E-government system

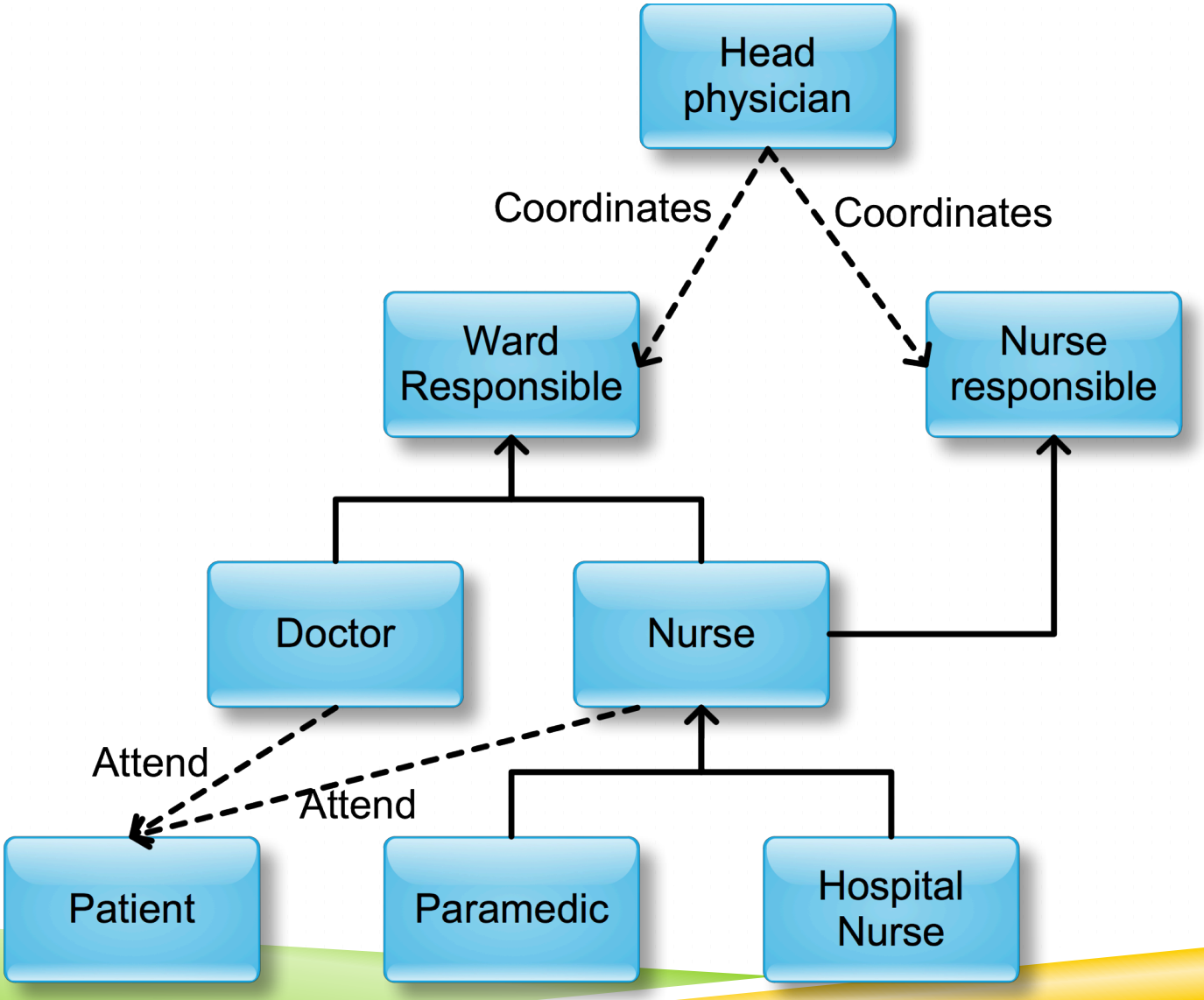
# LINKING SECURITY REQUIREMENTS IN STSs

# STS REQUIREMENTS

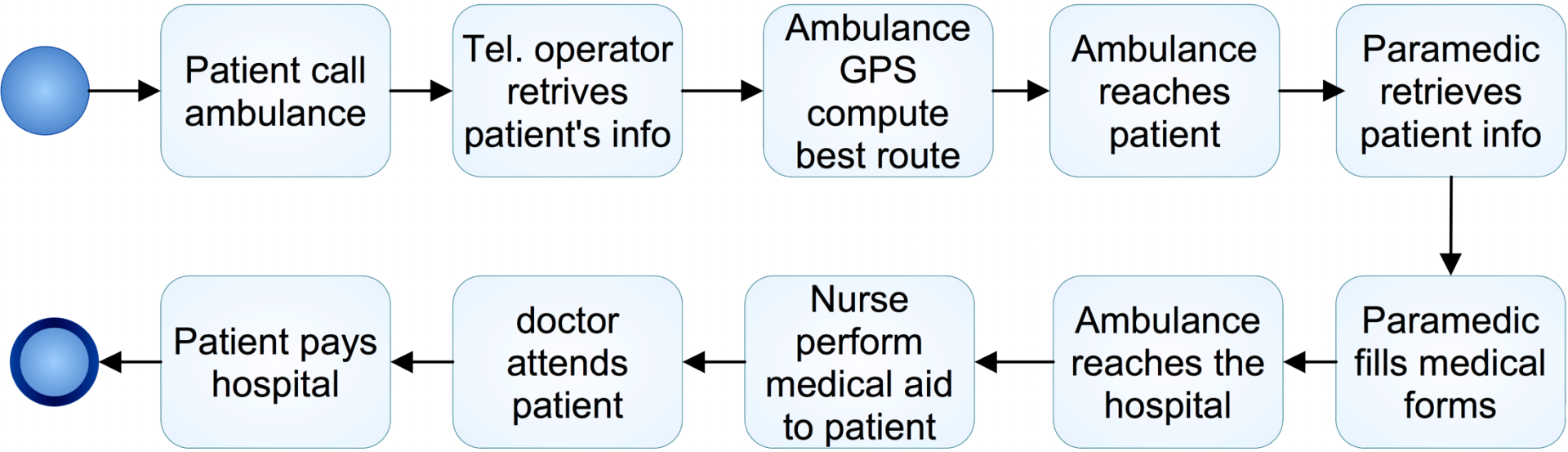
- Organization structure
  - The typically hierarchical arrangement of lines of authority, communications, rights and duties of an organization[1].
- Processes
  - A collection of activities that takes one or more kinds of input and creates an output[6].
- Technologies
  - Hardware and software functional to the execution of activities in processes

# HCS EXAMPLE - SANTA CHIARA HOSPITAL

# HCS EXAMPLE – ORGANIZATION STRUCTURE



# HCS EXAMPLE - PROCEDURE



# HCS EXAMPLE - TECHNOLOGIES

- PDA for doctors and nurses
  - Access to Hospital Data Base(DB), municipality DB
  - Medical forms compilation
  - Direct connections to other PDA
- GPS navigator for paramedics
  - Search fastest route



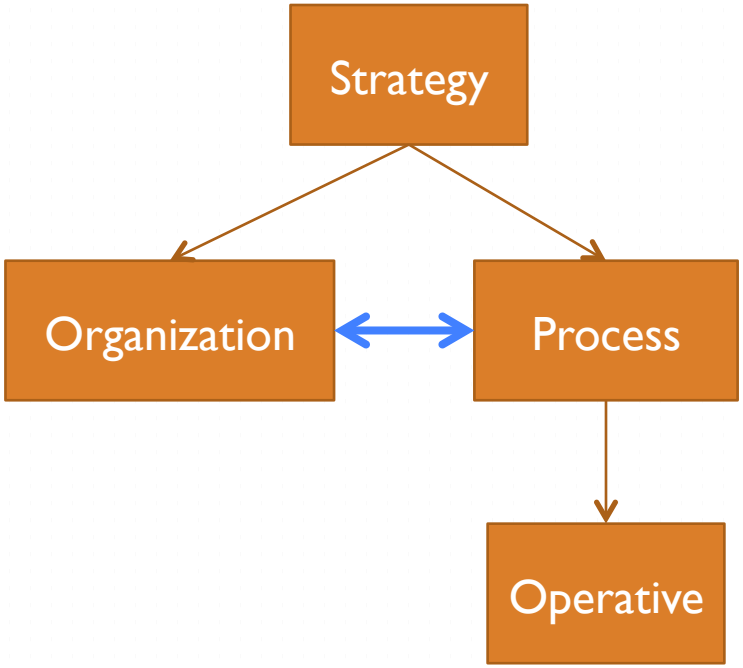


# LINKING STSs REQUIREMENTS

- Lot of languages characterize each type of STS requirements
  - Organizational structure requirements
    - E.g. UML deployment diagram[7], UML component diagram[7], MEMO[9], UEML[8]
  - Procedural requirements
    - E.g. BPMN[10], EPC[12], YAWL[11], UML sequence diagram[7], UML activity diagram[7]
  - Technological requirements
    - E.g. UML class diagram[7], Conspec [4], WSLA[13], WSAg[14]
- Are organizational, procedural and technological requirements independent?
  - Organizational and procedural requirements
  - Procedural and technological requirements

# BUSINESS MODEL CHARACTERIZATION[2]

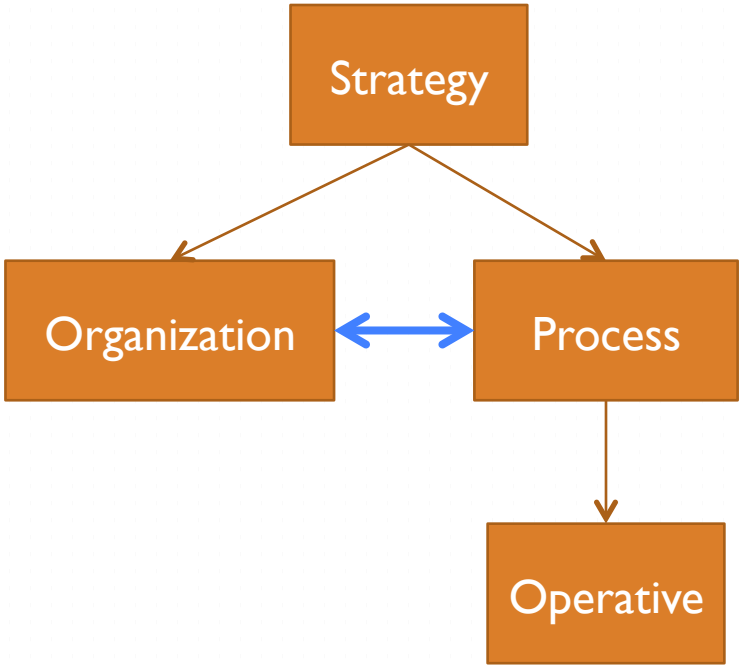
- Strategy
  - Long term objectives of a firm (5-10 years)
- Tactic
  - Medium term objectives of firm (2-5 years)
  - Organization
  - Process
- Operative
  - Short term objectives (up to 2 years)
  - Technologies used



# BUSINESS MODEL CHARACTERIZATION

Example:

- Strategy
  - Maintains high HCS surgery quality
- Tactic
  - Organization: at least two supervisors for every surgery session
  - Process: procedure to train new doctors
- Operative
  - All video of surgery sessions can be downloaded from an internal database



# SECURITY IN STSs

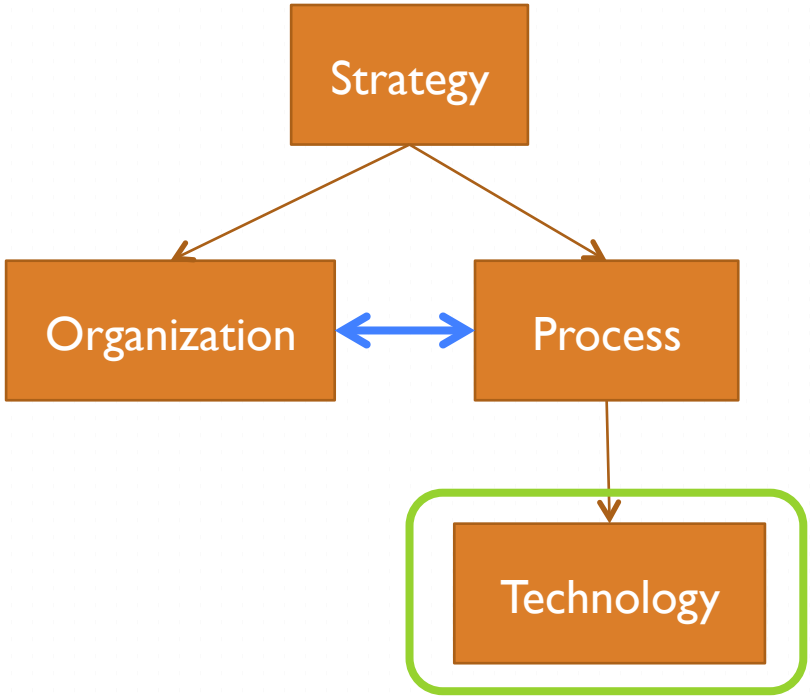
- Security is a central issue in STSs
  - Legal and financial consequences
- It is not only a technological problem
  - It is analyzed from as strategic, process, organizational and technological problems

# TECHNOLOGICAL SECURITY REQUIREMENTS

Security requirements about functional characteristics of STSs

Examples:

- Doctors' PDA transmits data using PGP encryption algorithm with 128 bits key length
- Paramedics' GPSs have a secondary battery

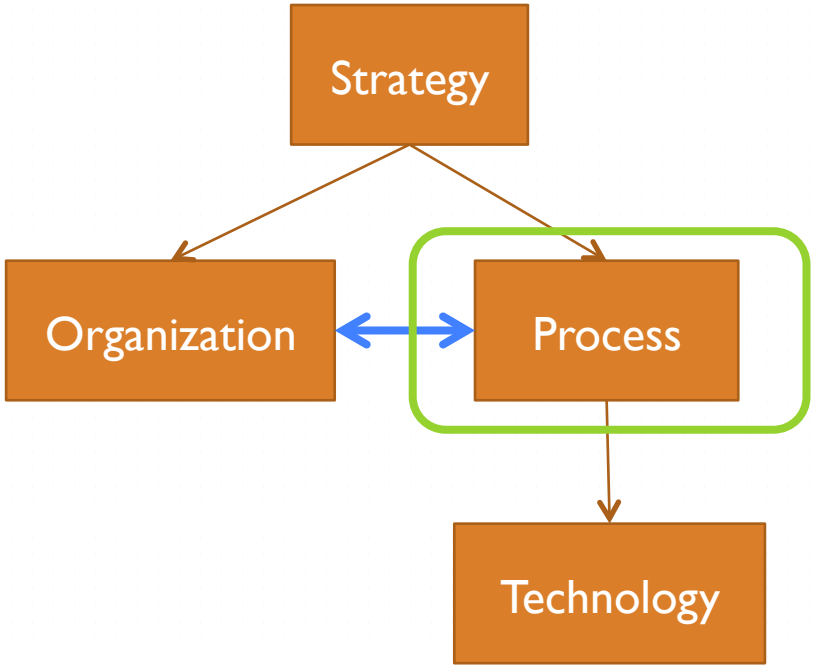


# PROCEDURAL SECURITY REQUIREMENTS

Security requirements about STS procedures

Examples:

- The HCS workflow manager receives and acknowledge from the performer who executes the activity "compute best route".
- The communication between activities "Compile medical forms" "Retrieve patient's info" is encrypted

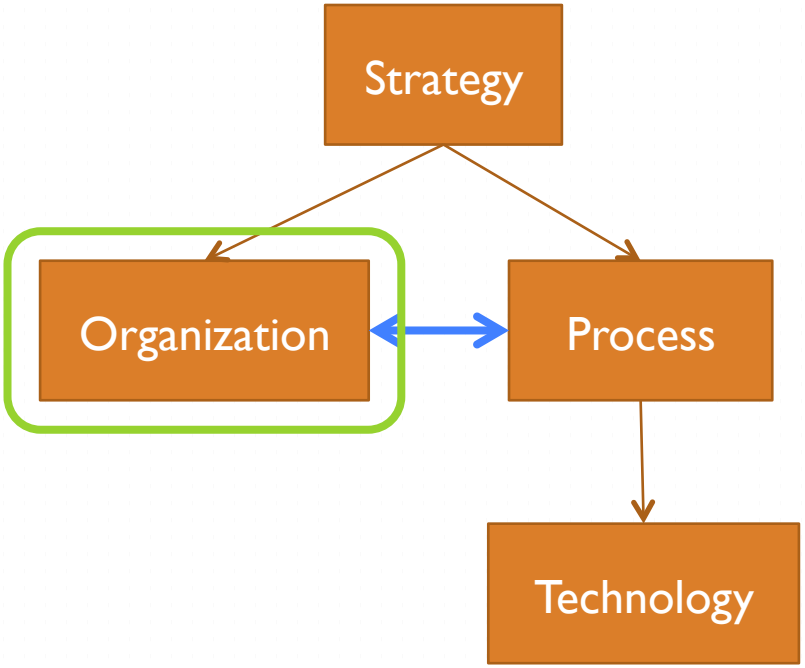


# ORGANIZATIONAL SECURITY REQUIREMENTS

Security requirements about organizational characteristics of STSs

Examples:

- Doctor will not repudiate the fact he/she healed a patient
- All HCS personnel will not disclose patients' sensitive information

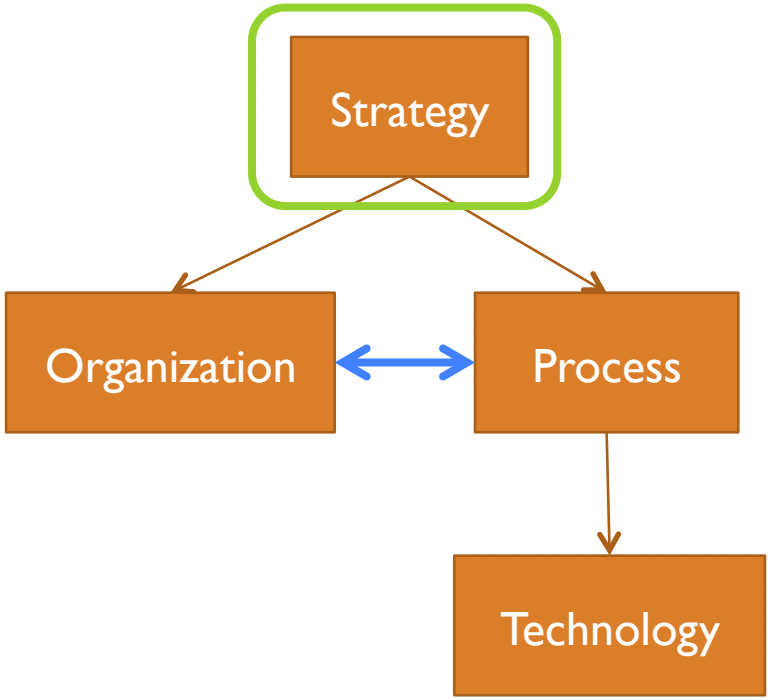


# STRATEGY SECURITY REQUIREMENTS

Security objectives linked to assets of STSs

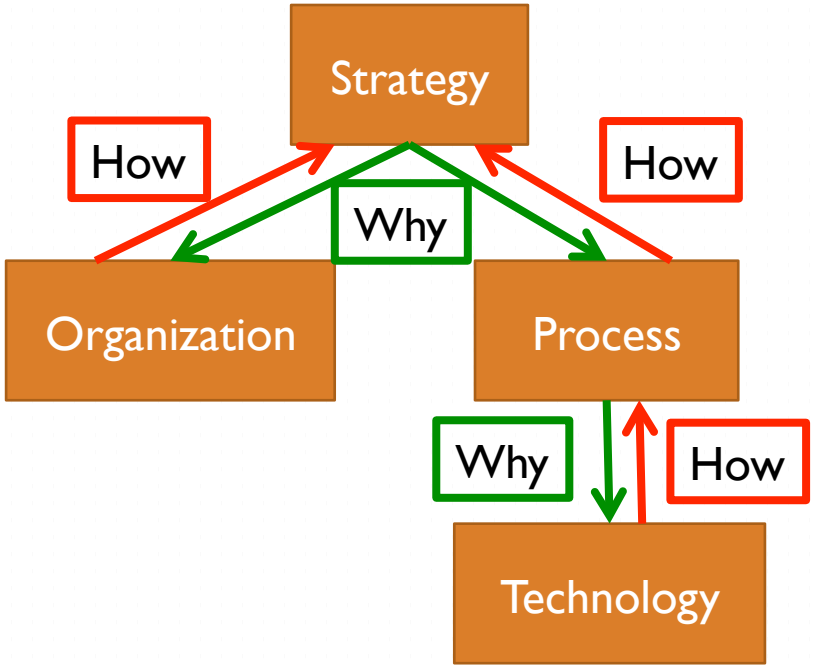
Examples:

- E.g. all HCS instruments will be used correctly
- E.g. reputation of hospital have to be preserved



# CONCEPTUAL LINKS

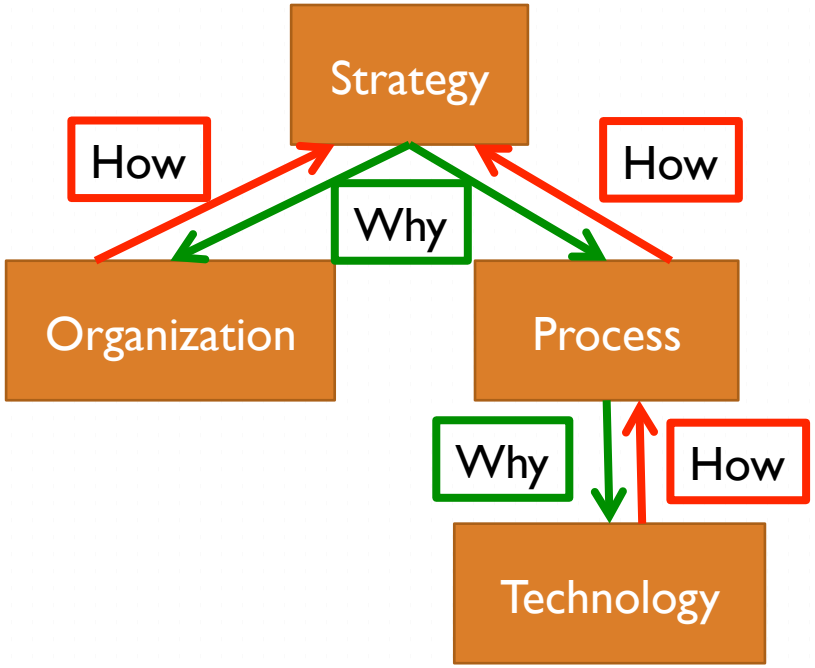
- Why/how relations
- Strategies answer questions on why a procedure/organization has certain characteristics
- Organizations/procedures answer questions on how a strategy is realized



# CONCEPTUAL LINKS

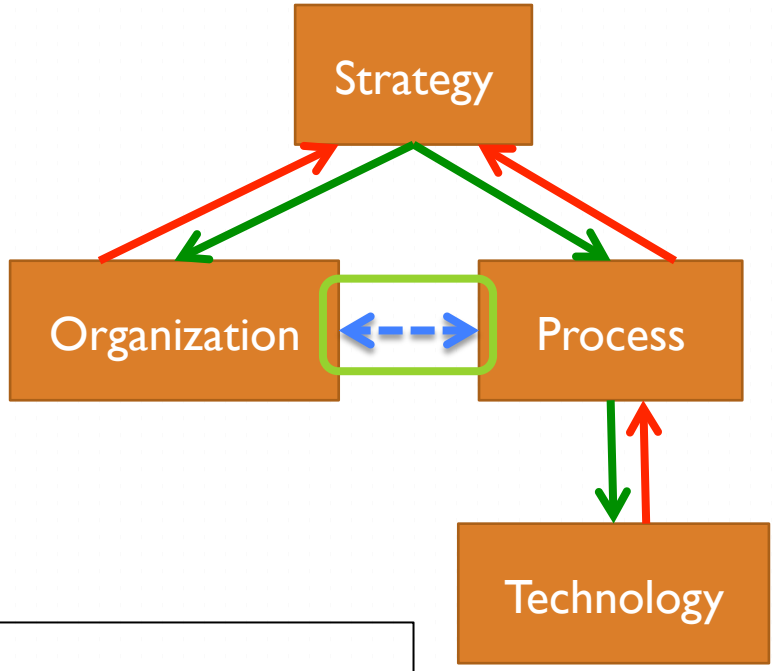
Example:

- Strategy
  - E.g. HCS sensitive information will not be misused
- Workflow
  - E.g. the communication between activities "Compile medical forms" and "Retrieve patients info" is encrypted



# ORGANIZATION AND WORKFLOWS LINK

- Organization and workflows security requirements must be coherent
- Process are designed on the basis of the organization structural requirements
- Procedural security requirements are directed influenced by organizational security requirements.



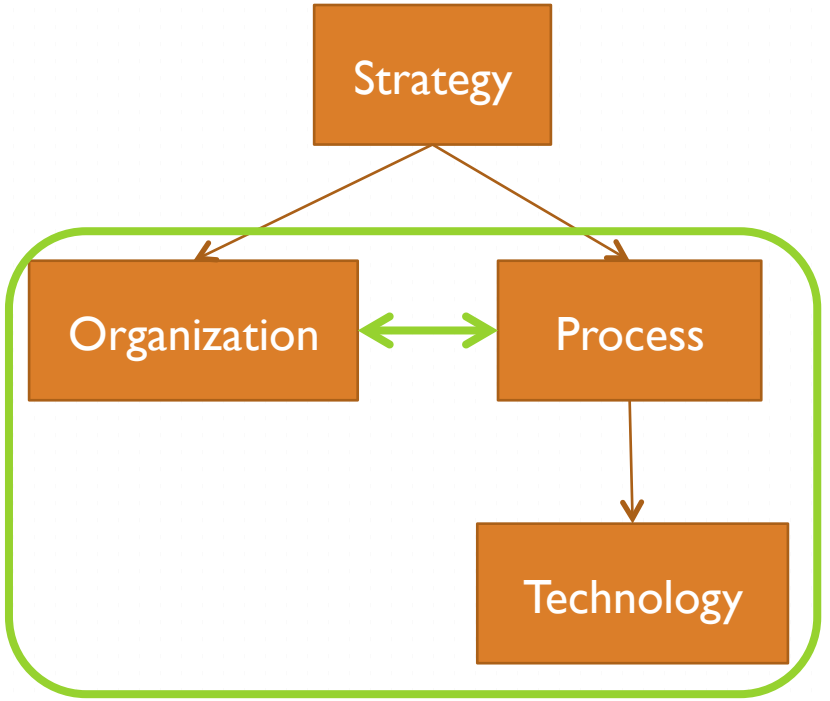

Example:

- Bind-of-duty between the roles of "ward responsible" and "nurse responsible"
- All the process where these two roles execute at least one activity, must enforce the bind-of-duty security requirements

# CHECKING ALIGNMENT OF SECURITY REQUIREMENTS

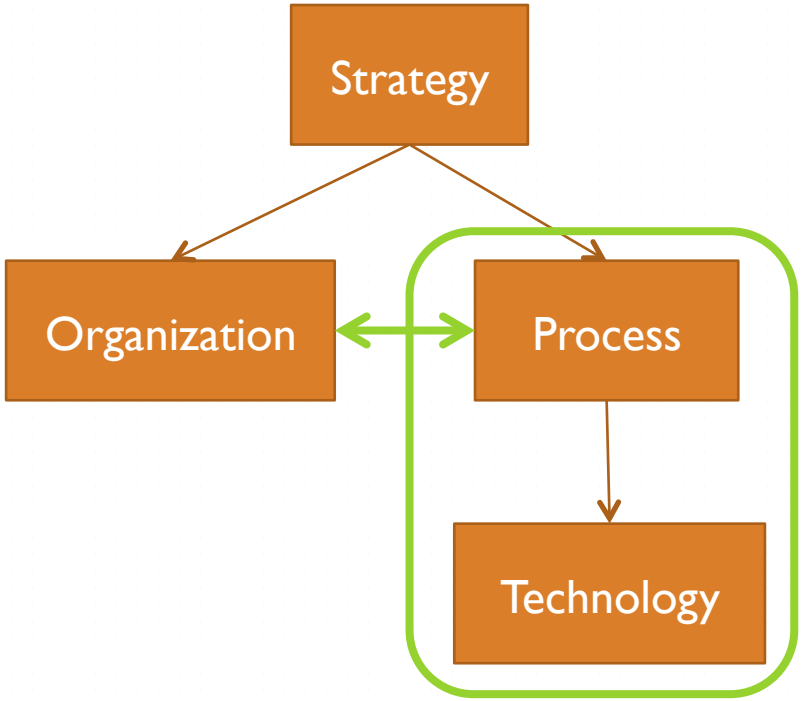
# ALIGNMENT OF SECURITY REQUIREMENTS

- Alignment: all security requirements are coherent
- If security requirements are not aligned consequences can be severe[3]

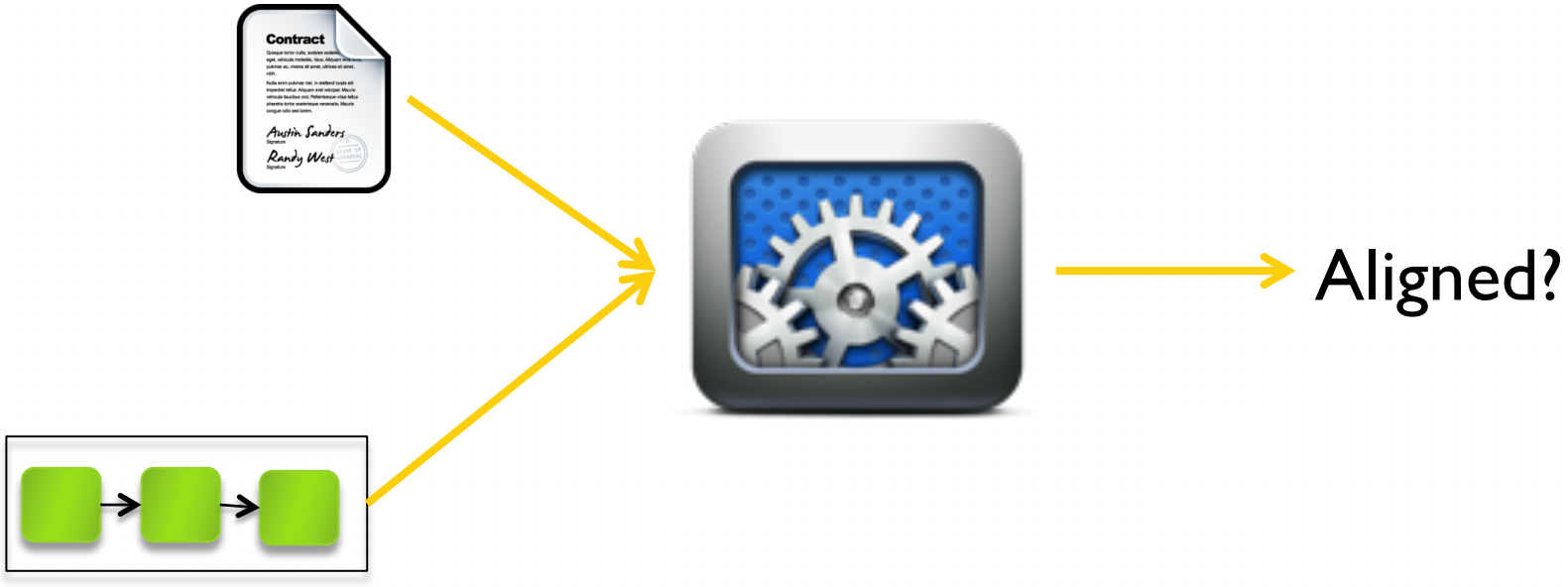


# PROCEDURAL-TECHNOLOGICAL ALIGNMENT

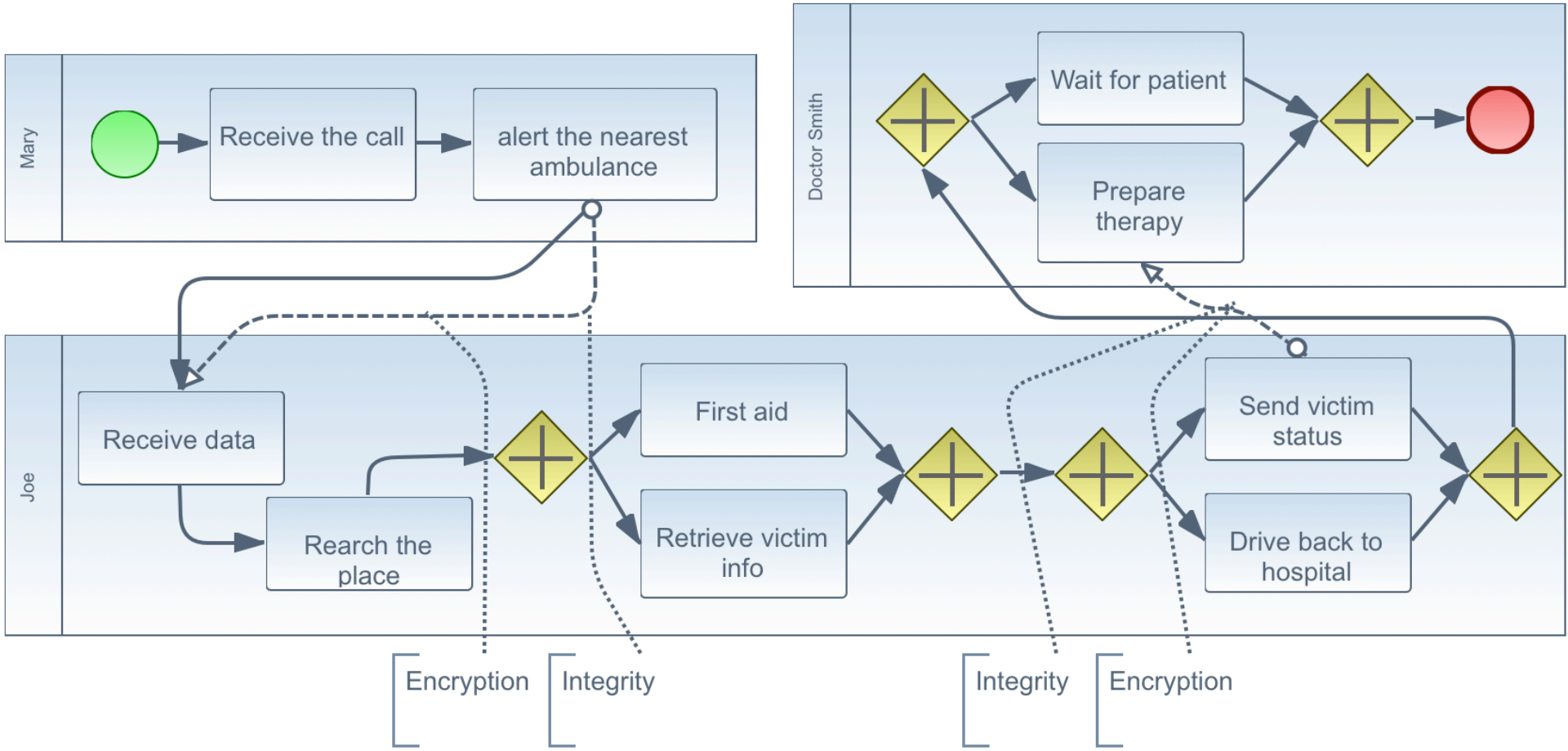
- Workflows security requirements
  - BPMN annotated with security requirements
- Technological security requirements
  - Conspec[4]
- Check
  - If security requirements expressed in annotated BPMN are enforced in Conspec.



# CHECKING ALIGNMENT ALGORITHM



# ANNOTATED BPMN 2.0

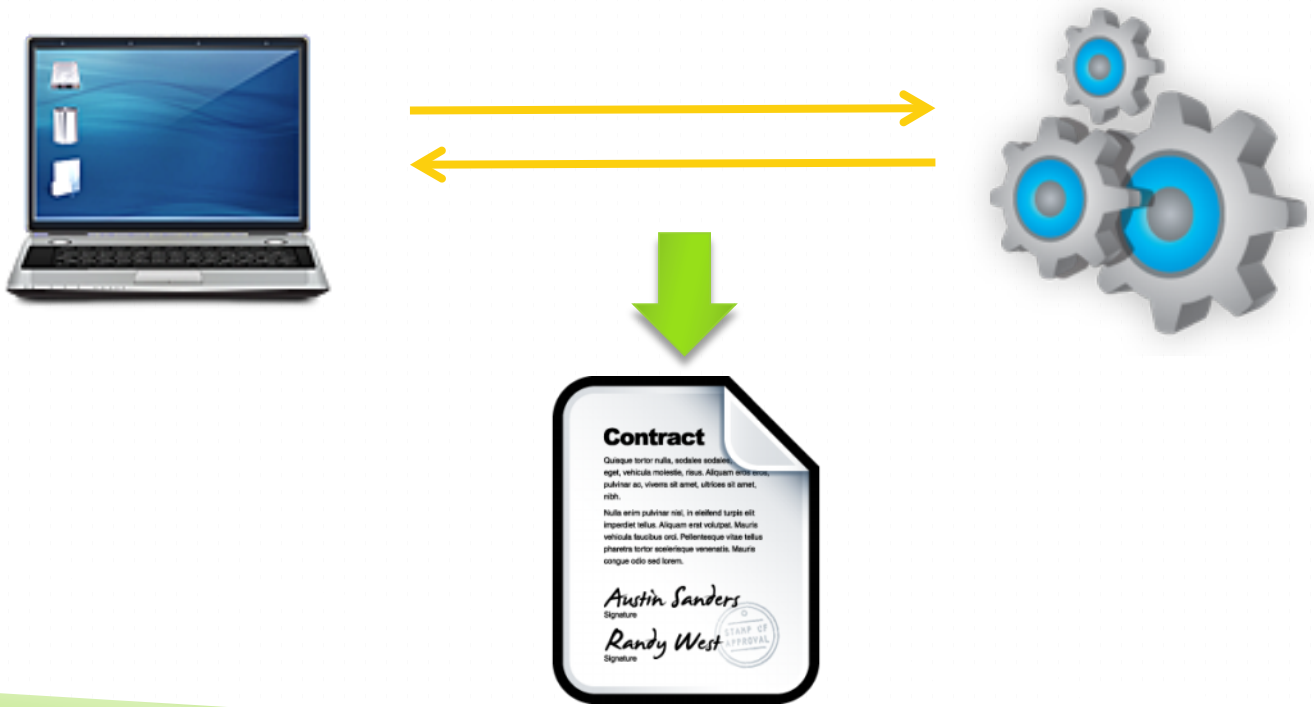


# PROCEDURAL SECURITY REQUIREMENTS

- **Integrity** (Call info, Alert the nearest ambulance, Receive data)
- **Encryption** (Call info, Alert the nearest ambulance, Receive data)
- **Integrity** (Victim status, Send victim status, Prepare therapy)
- **Encryption** (Victim status, Send victim status, Prepare therapy)

# CONTRACTS

- STSs : interaction between autonomous technological components
  - Service-oriented Architecture (SOA)



# CONSPEC

SECURITY STATE

string sendingService = <S1>;

string receivingService = <S2>;

string CommunicationName = <C1>;

Boolean encrypt = false;

**BEFORE** v#activity.end(string name, int time, int date, string exec, stream output) **PERFORM**
name == sendingService && encrypted == v#input.isEncrypted(PGP)—> {skip}

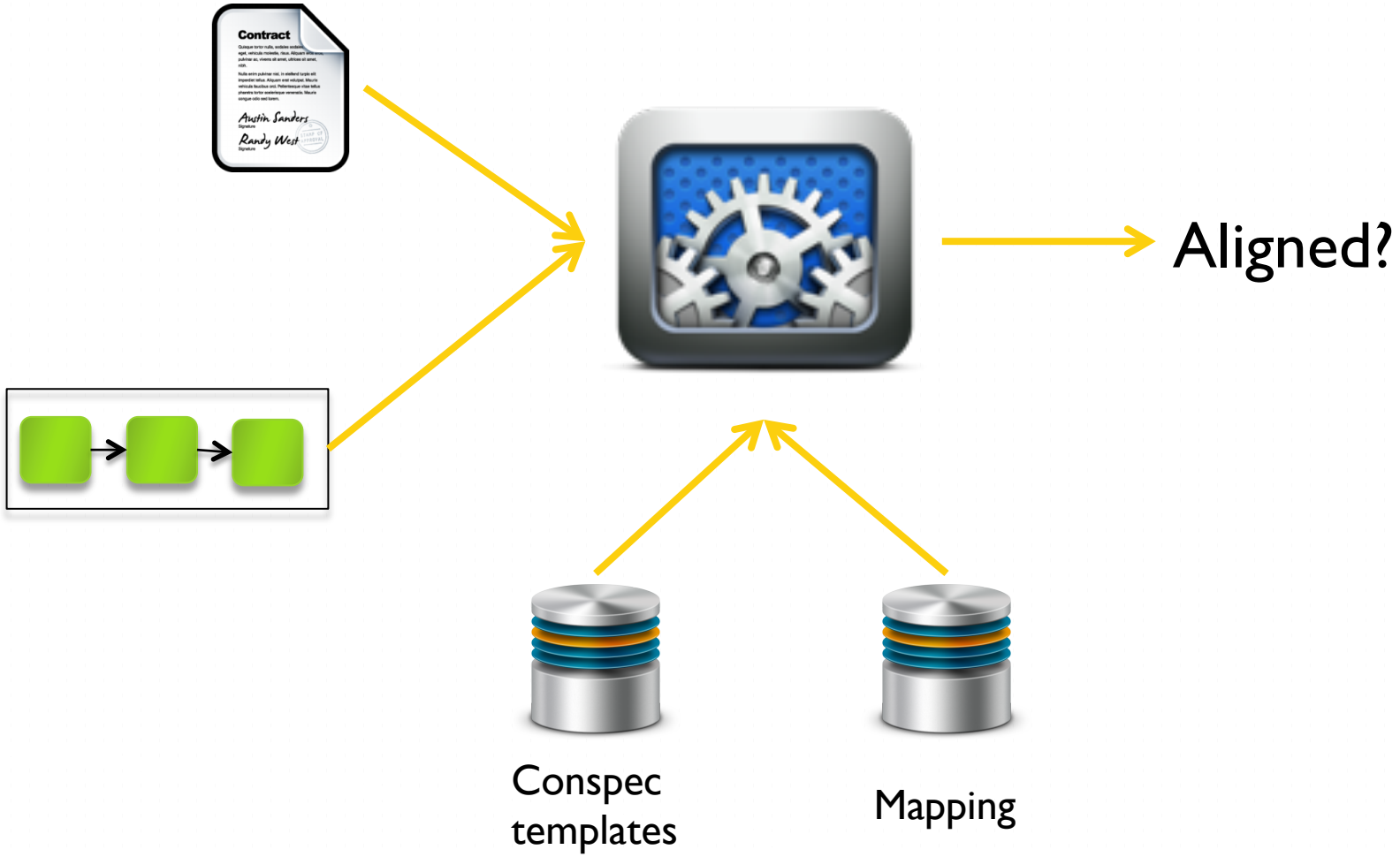
!(name == sendingService) —> {skip}

**BEFORE** v#activity.start(string name, int time, int date, string exec, string input) **PERFORM**

name == receivingService && communicationName==input.getName && encrypted(PGP) —> {skip}
name == receivingService && !communicationName==input.getName —> {skip}

!(name == receivingService) —> {skip}

# CHECKING ALIGNMENT ALGORITHM



# STEPS FOR CHECKING ALIGNMENT

1. Translate parameters of procedural security requirements
2. Instantiate procedural security requirements
3. Search technological security requirements

# 1- TRANSLATION OF SECURITY PROPERTY PARAMETERS

- Change parameters using a map provided by user

**Example:**
**Encryption** (Call info, Alert the nearest ambulance, Reach the place)

| BPMN element | Conspec element |
|---|---|
| Call info | healthcare.gov/res/callInfo |
| Alert the nearest ambulance | healthcare.gov/services/alertParamedic |
| Receive data | healthcare.gov/services/ambulance/receiveData |

**Encryption** (healtcare.gov/res/callInfo, healtcare.gov/services/alertParamedic, healtcare.gov/services/receiveData)

# 2- INSTANTIATE PROCEDURAL SECURITY REQUIREMENTS

- Generate the Conspec contract correspondent to the security policy
  - **Encryption** (healtcare.gov/res/callInfo, healtcare.gov/services/alertParamedic, healtcare.gov/services/receiveData)
- Use repository of Conspec contract template
  - Conspec contracts with placeholders

# CONSPEC - TEMPLATE

SECURITY STATE

string sendingService = **<S1>**;

string receivingService = **<S2>**;

string CommunicationName = **<C1>**;

Boolean encrypt = false;

**BEFORE** v#activity.end(string name, int time, int date, string exec, stream output) **PERFORM**
name == sendingService && encrypted == v#input.isEncrypted(PGP)—> {skip}

!(name == sendingService) —> {skip}

**BEFORE** v#activity.start(string name, int time, int date, string exec, string input) **PERFORM**

name == receivingService && communicationName==input.getName && encrypted(PGP) —> {skip}
name == receivingService && !communicationName==input.getName —> {skip}

!(name == receivingService) —> {skip}

# 3- SEARCH TECHNOLOGICAL SECURITY REQUIREMENTS

- Search the generated policies in all contracts
- Text search :
  - Bitap [5]
    - approximate string matching algorithm O(nm)*
  - Boyer et al. [6]
    - most efficient string search algorithm O(n)*

* **m** is the length of the pattern and, **n** is the length of the searchable text.

# CHECKING COMPLIANCE ALGORITHM

```
1  checkAlignmentSO (
2  Set<SecurityProperty> SP_set, Set<Template> template_set,
3  Set<Contract> contract_set, Mapping mapping
4  )
5
6  Boolean aligned = true
7  while !SP_set.empty && aligned
8    SecurityPropery SP = SP_set.pop
9    Set<TranslatedSecurityPropery> TSP_set=translate(SP, mapping)
10   Set<InstantiatedSecurityPolicy> ISP_set=instantiate(TSP_set, template_set)
11   for each  Contract C in contract_set
12     if ISP.involvedParty.contains(contract.provider)
13       Set<Contract> involvedContract_set.insert(C)
14   Boolean found = false
15   while !found && aligned
16     InstantiatedSecurityPolicy ISP = ISP_set.pop
17     for each contract C in involvedContract
18       if search(ISP, C)
19         found = true
20         break
21     if found = = false
22       aligned = false
23       break;
24 return aligned
```

# SUMMARY – FUTURE WORK

- We established link between different type of security requirements
  - Formalize link
- We defined the algorithm which checks the alignment between procedural and technological security requirements
  - Implement the algorithm
- We defined a semi-automated framework which checks alignment of organizational, procedural and technological security requirements.
  - Validate the framework with case studies

# THANK YOU!

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