2

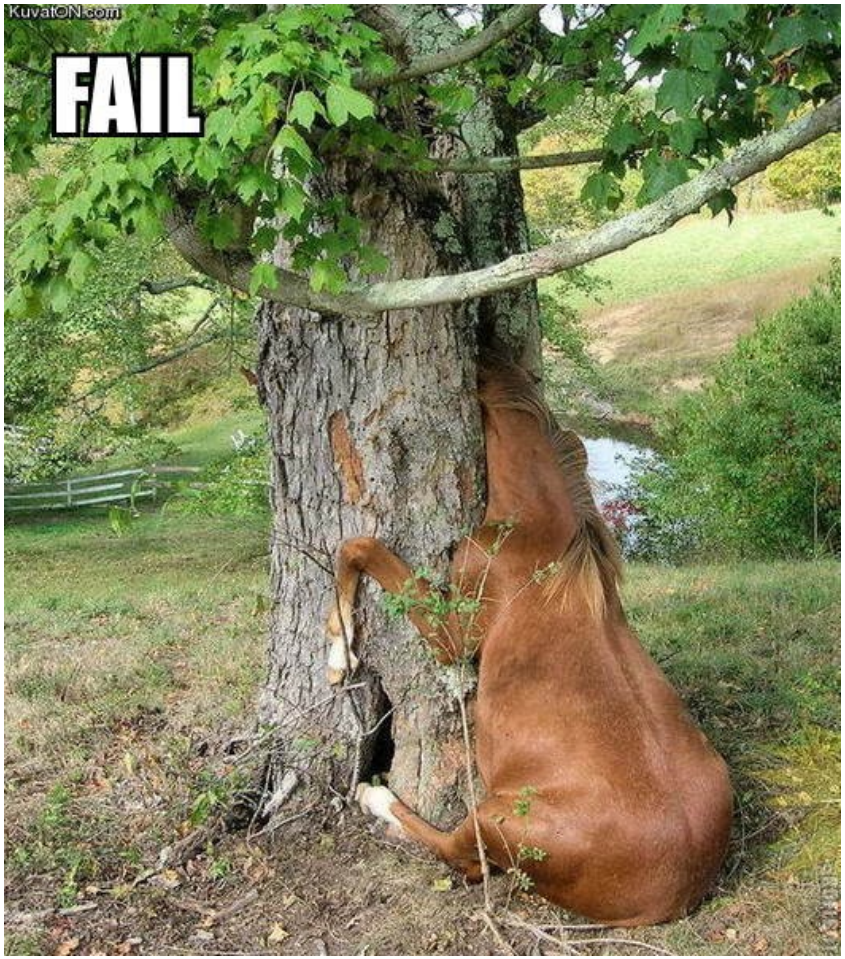
- The correctness problem
  - the machine and the world
  - users are part of the world
  - users & customers
  - distribution infrastructure

The correctness problem

- When is a software system **correct**?
  - "it compiles fine!"
  - "it works!"
  - "it has a nice GUI!"
  - "it is **k**▪**o**▪**o**▪**l**!"
  - "it does what it advertises"
  - "it was delivered in-time"
  - "the letter of the contract was respected"

The correctness problem

- When is a software system **correct**?
  - the implementation fully respects the specification
  - passed all the test suites successfully
  - we are getting 0 support calls on the hotline
  - we had our best team on the project
  - customer did not sue us



The correctness problem

- An interesting product: the DVD rewinder

The correctness problem

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The correctness problem

- **A software system is correct if, once deployed, it brings the world into a desired state**
- Essentially, correctness = satisfaction of requirements
- Provided that
  - requirements are stated w.r.t. the state of the world, not w.r.t. the system itself
  - requirements are feasible w.r.t. available resources and external constraints

The correctness problem

- For the formally-inclined:

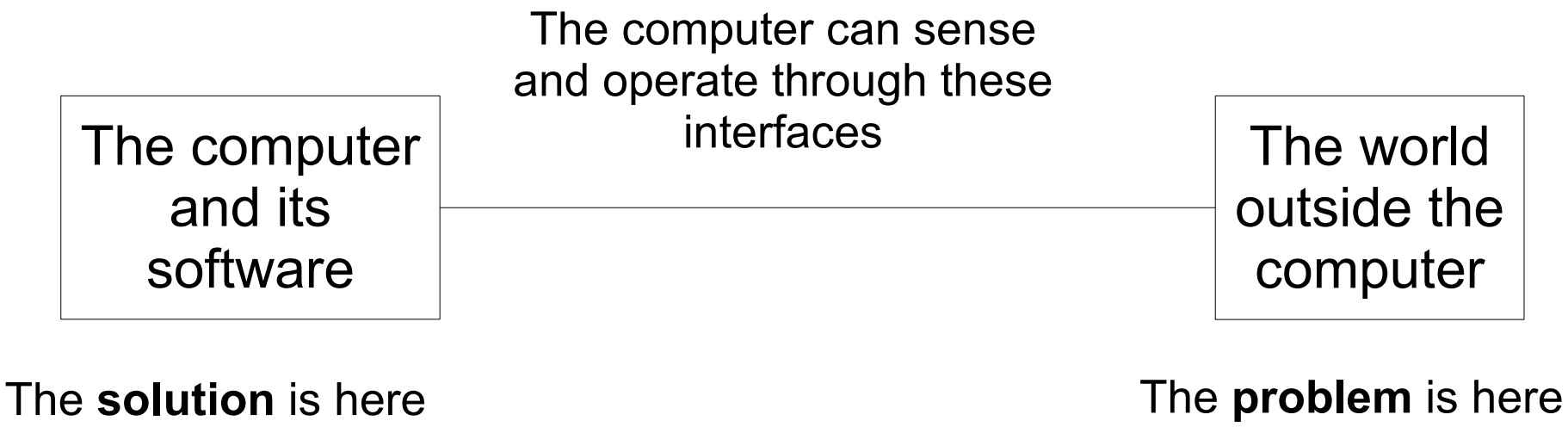
$$S \cup D \models R$$

- That is: the behaviour of the system, as specified by *S*, deployed in the world, as described by *D*, entails (i.e., satisfies) the requirements, as documented by *R*

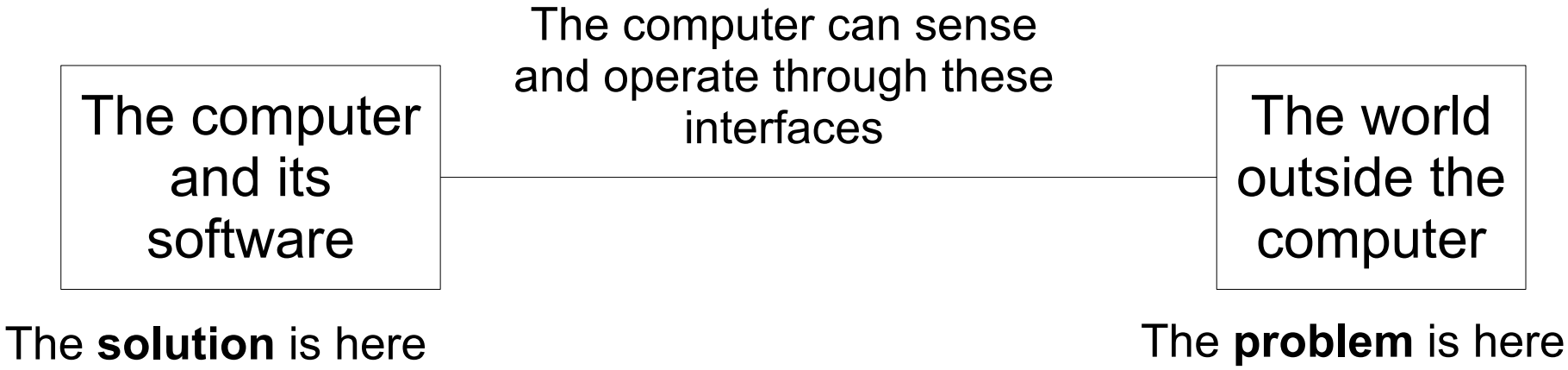
The machine and the world

- Following Michael Jackson's (not the singer) terminology, we will distinguish three elements
  - the **machine**
    - typically, computer+software (the software turns an all-purpose computer into a specialized machine)
  - the **world**
    - everything, but the machine
  - the **interfaces**
    - shared phenomena between machine and world

The machine and the world



The machine and the world



- The problem is **not** in the machine
  - "The system shall do this and that" - wrong!
- The problem is **not** at the interface
  - neither GUI nor sensors/actuators
- Problem is farther away from the computer
  - e.g., what do people do while they are not interacting with the computer?

Structuring the world

- “The world” is a short word for something so large
- In practice, we structure it in a number of **problem domains** which help in bounding the problem
- Each domain abstracts a cohesive part of the real world (from the point of view of our problem)
- Problem domains and machine domain interact through **shared phenomena**

Structuring the world

- Users are modeled as a domain
- Human-computer interaction is described through phenomena shared between users and machine
- Not only GUIs

Structuring the world

- Communication infrastructure can be modeled as a domain
- Many relevant phenomena!
  - Delays; Faults & Failures; Cost; ...

Structuring the world

- Some distribution infrastructures are part of D
  - Internet
  - Cellular networks
  - Land lines connecting shops to banks
  - Credit card marketing and distribution
- Others can be designed and are thus part of S
  - The high-speed communication backplane in a massively parallel computer
  - The exact format of which SMS are sent by a car theft tracking device

An example

- The Patient Monitoring Problem
  - (from M. Jackson, “Problem Frames”, 2001)

A patient monitoring program is required for the ICU in a hospital. Each patient is monitored by an analog device which measures factors such as pulse, temperature, blood pressure, and skin resistance. The program reads these factors on a periodic basis (specified for each patient) and stores the factors in a database. For each patient, safe ranges for each factor are also specified by medical staff. If a factor falls outside a patient's safe range, or if an analog device fails, the nurses' station is notified.

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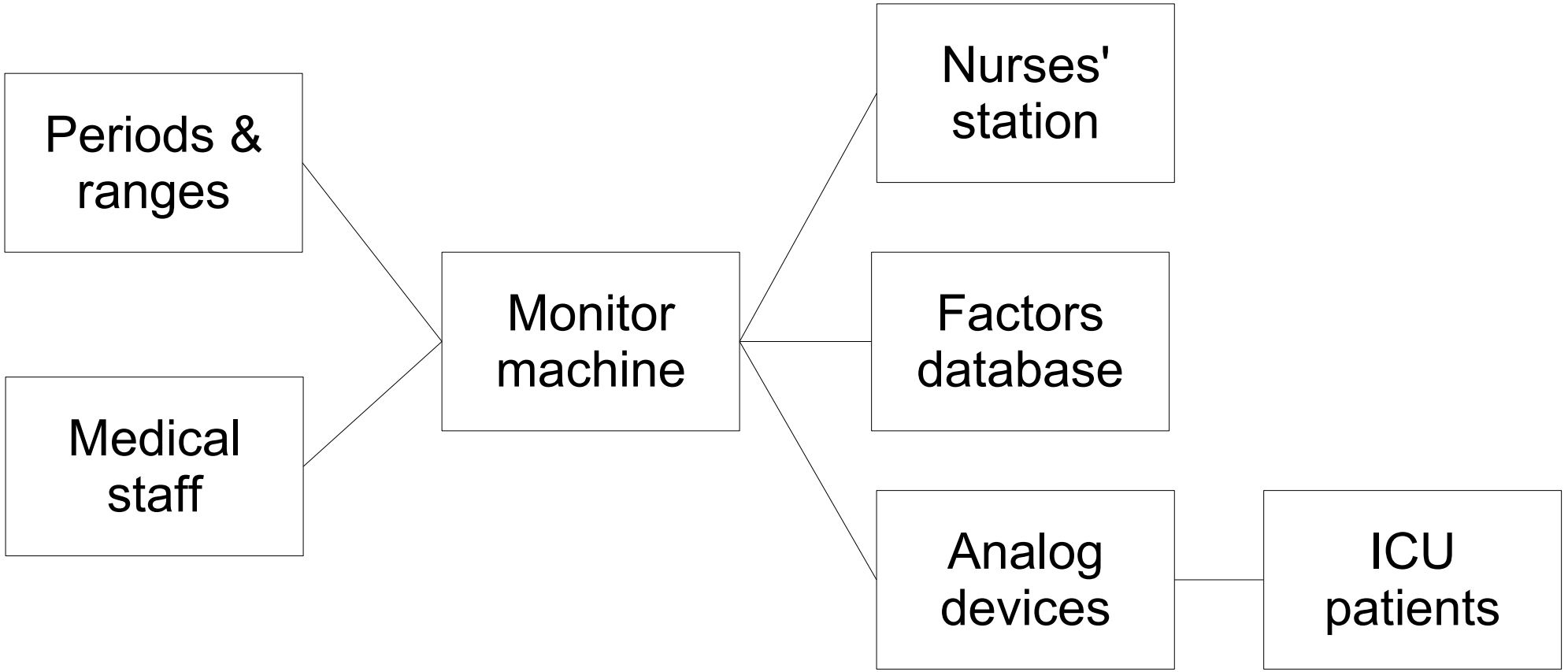
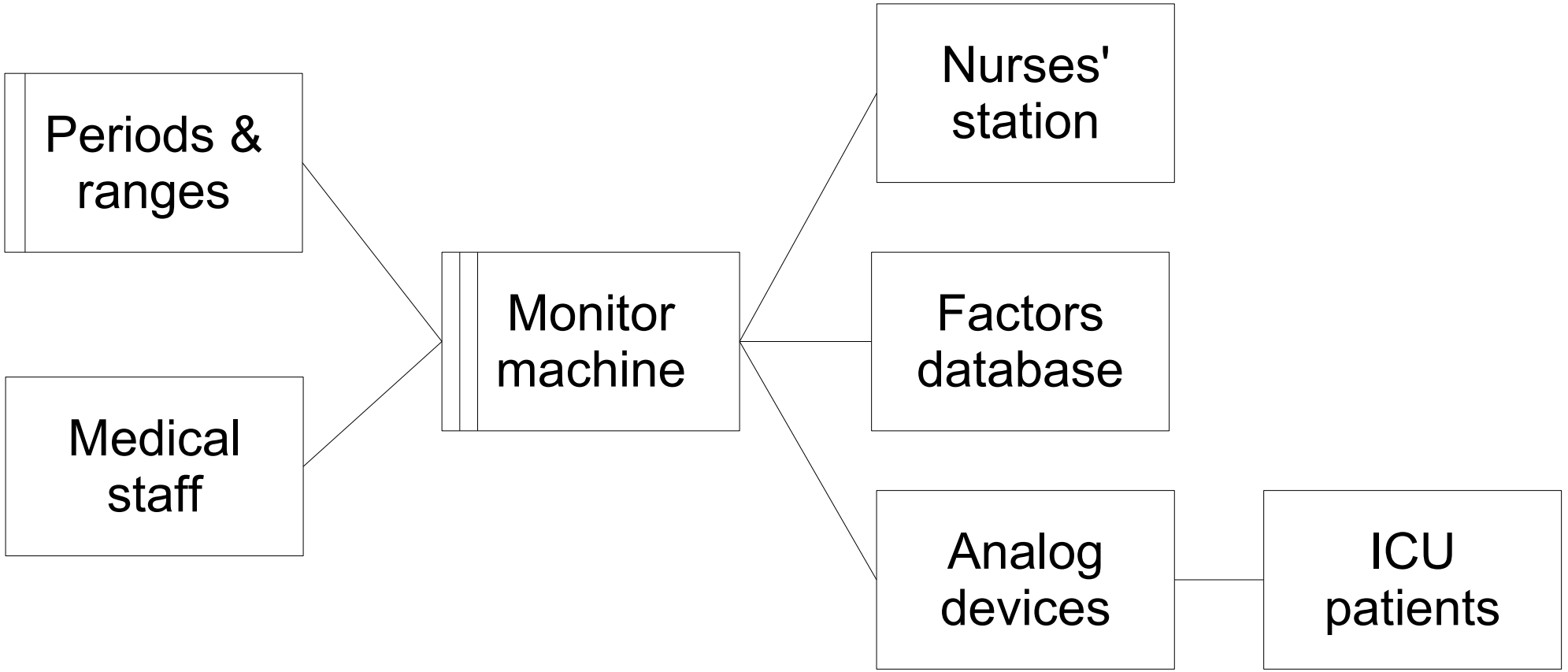

Periods & ranges
Medical staff
Monitor machine
Nurses' station
Factors database
Analog devices
ICU patients

Domains

- All domains are **physical**: they must be **observable** in the real world
- Three types of domains
  - **machine** domain
    - the computer and its software; to be designed
  - **designed** domain
    - a physical representation of some information (e.g., screens, data on disk, printouts), can be designed (at least in part, e.g. layout)
  - **given** domain
    - all properties given, to take “as is”

An example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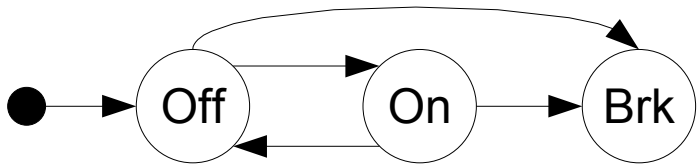
Domains

- Moreover, domains can be:

C

  - **Causal**, if they guarantee certain causal relationships so that we can predict, given some phenomenon, how the domain will react
    - example: a light bulb is a causal domain; given suitable current, it will emit light
    - counter-example: it could break!
    - counter-counter-example:



Domains

- Moreover, domains can be:
  - **Biddable**, if they can be asked to do something, but we have no guarantee that they will react accordingly
    - most often, a biddable domain will consist of people
    - humans don't like being given instructions by a computer, yet in a whole-system view this is very common
    - example: bill of shipment to be loaded on a truck

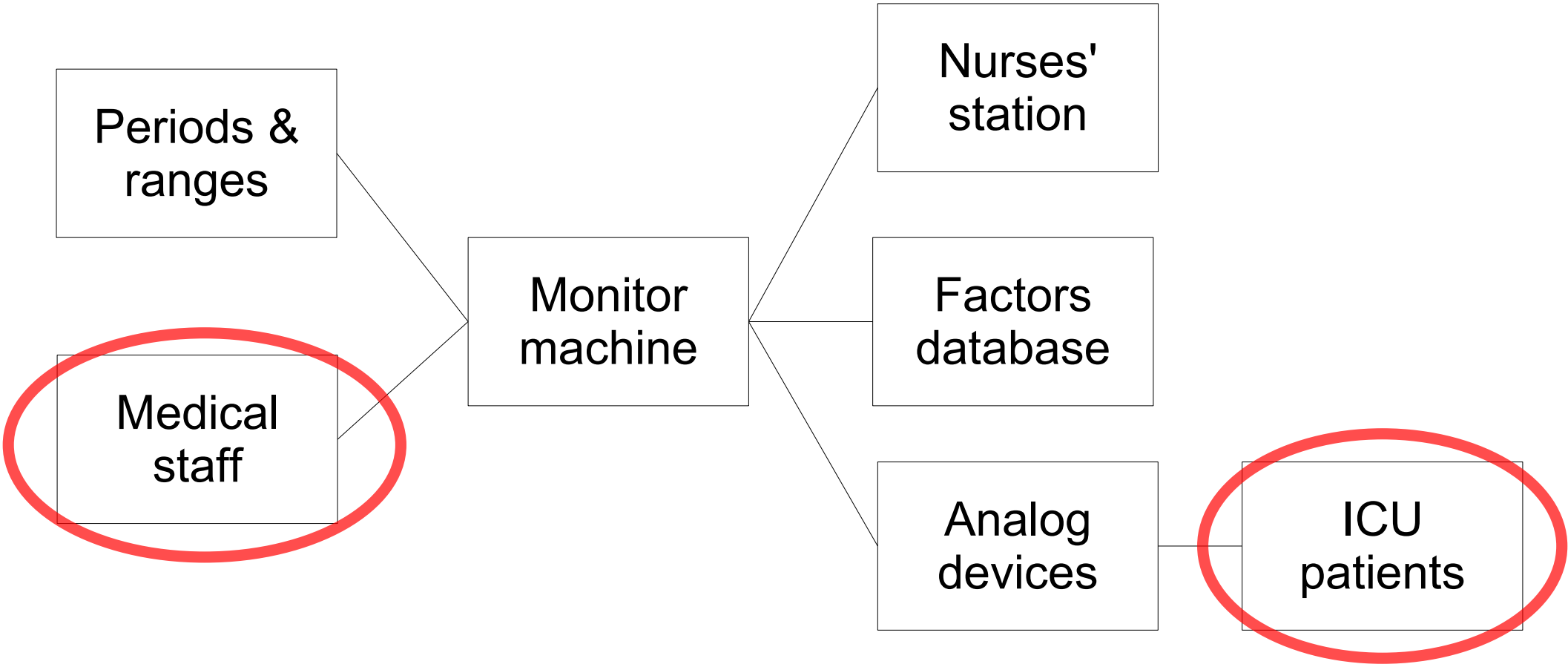
Domains

- Moreover, domains can be:
  - **Lexical**, if they consists of symbols to be manipulated, or in general of a physical representation of data
    - lexical domains share some trait of causal domains, e.g. write and read of data will (usually) work as expected
    - in most other respects, they can be treated as purely passive data
    - example: source program for a compiler

Users are part of the world

- Users are typically a *biddable given* domain
  - the machine can only ask and hope for the best
  - the designer cannot “program” the users
- A large part of the analysis focuses on the phenomena shared between the machine and these domains
  - the right phenomena: correctness
  - suitable physical counterparts: interface design
  - efficient and robust

Humans: not only users



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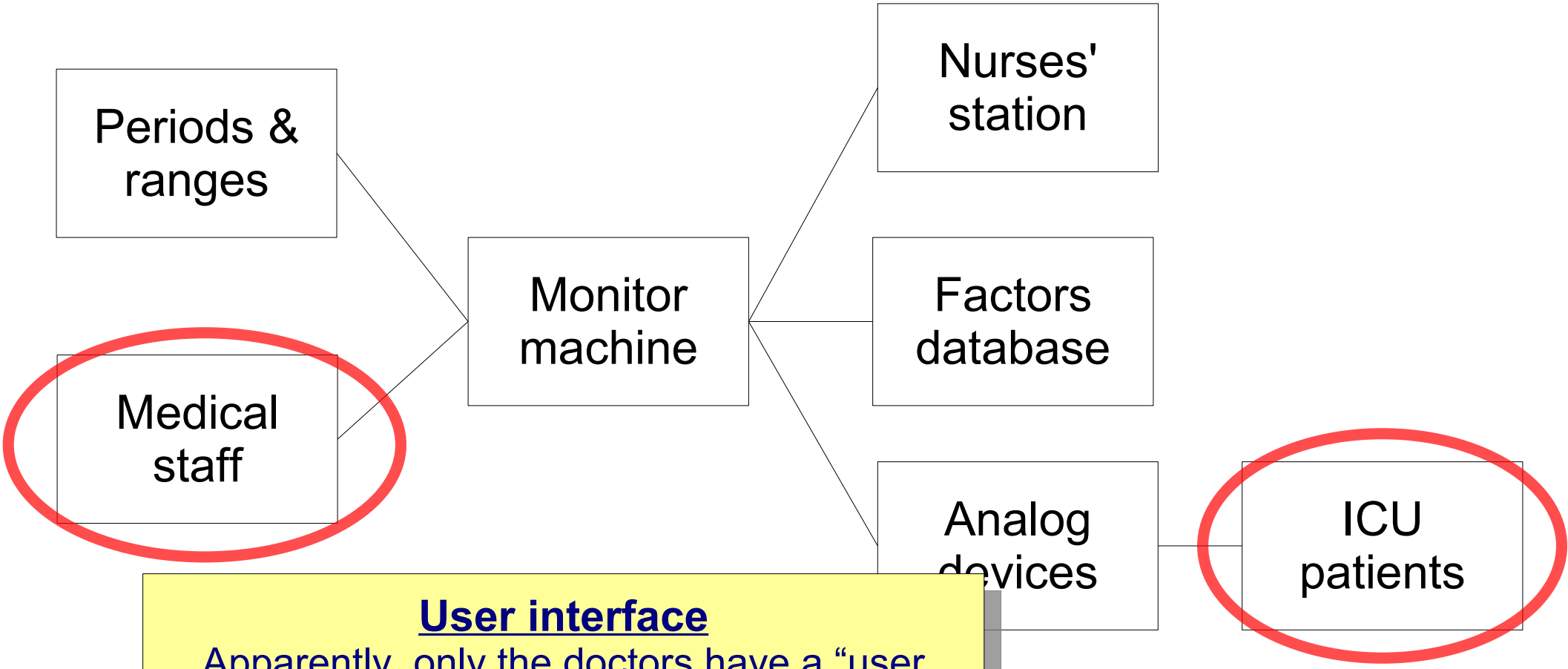
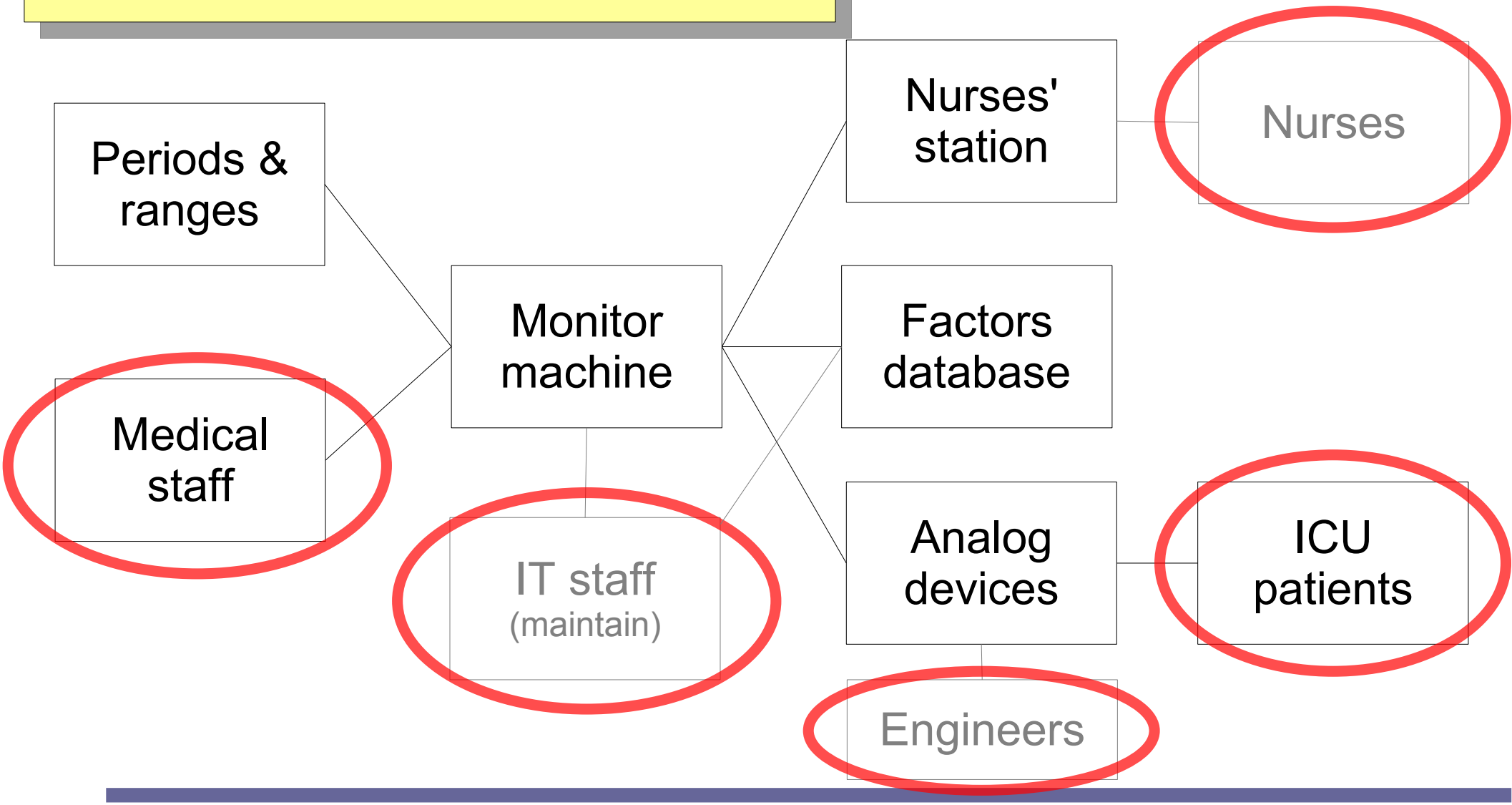


User interface

Apparently, only the doctors have a “user interface” to the machine (to enter a patient's periods&ranges)

sers

User interface
But many other humans have a role in the case: the overarching goal is to provide for the health of the patients



Users and customers

- Typically, the customer pays for the satisfaction of users' desires
- But that is not always the case:
  - more efficient ticket-machines on buses
  - border surveillance applications
  - peer-2-peer blocking software
  - digital rights management
  - locked-down systems
- (there is always the “higher good” excuse)
- The customer pays, his voice is higher!

Distribution infrastructure

- "Best-effort" communication schemes are **biddable**
  - You can ask deliver, hope it will happen
  - Example: UDP over IP
- "Guaranteed delivery" communication schemes are **also** biddable!
  - Wait! Wasn't TCP/IP supposed to be causal?
  - Yeah... 404 NOT FOUND
- It is rarely safe to assume **causal** infrastructure
  - Very robust infrastructure, or
  - Low-assurance system

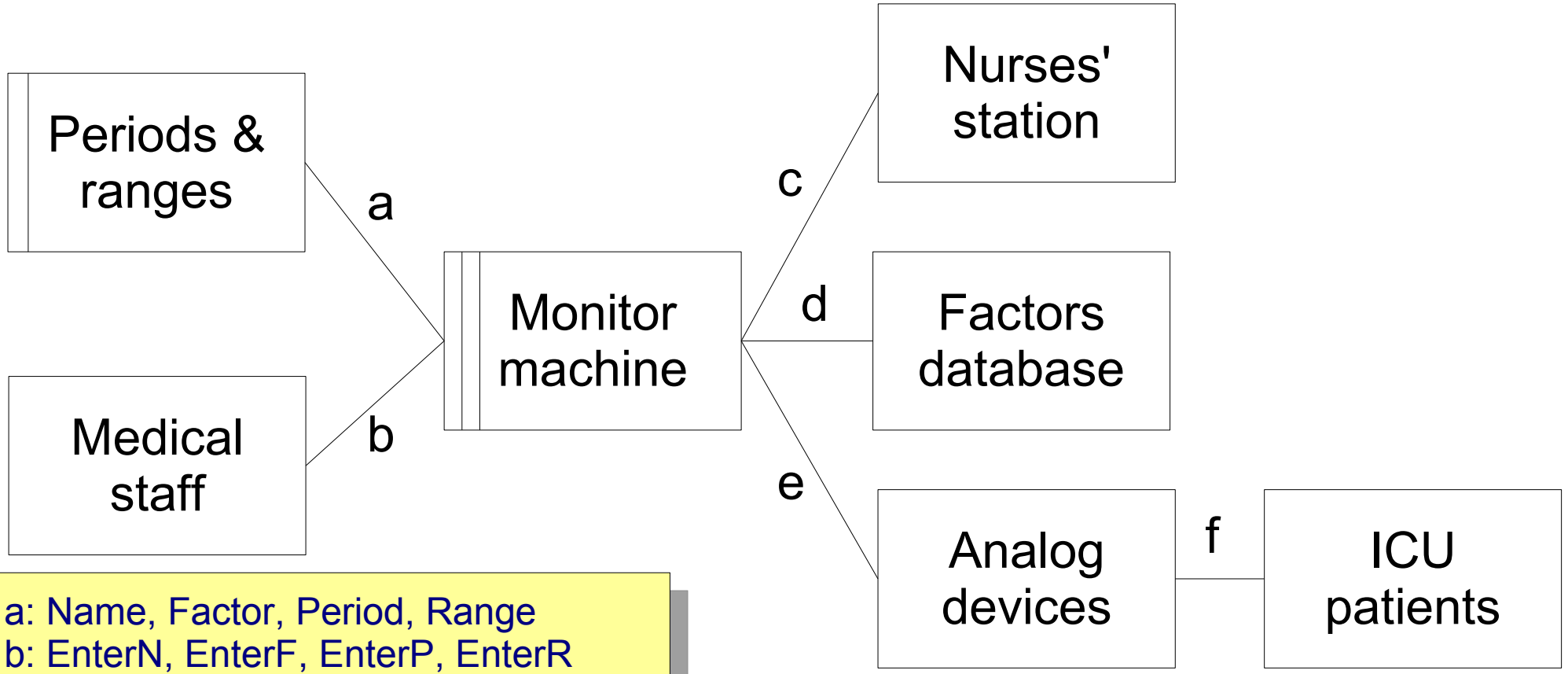
Interfaces as shared phenomena

- It is important to distinguish the notion of **domain interface** from that of user interface
- A domain interface is **a set of shared phenomena** (events, states, values, ...)
- All domains in an interface **participate** of the phenomena; only one can **cause** a given phenomenon
- Phenomena can carry information (parameters)

Types of phenomena

- Individuals
  - Events: an instance of something happening
  - Entities: something that persists over time
  - Values: an element from same (algebraic) sort
- Relations
  - States: relations between entities and values
  - Truths: predicates between individuals (static)
  - Roles: relations between events and individuals
- We will skip the formal parts and rely on intuition in the following

An example



a: Name, Factor, Period, Range
b: EnterN, EnterF, EnterP, EnterR
c: Notify
d: StoreFactor
e: RegisterValue
f: FactorEvidence

Exercise: what else?

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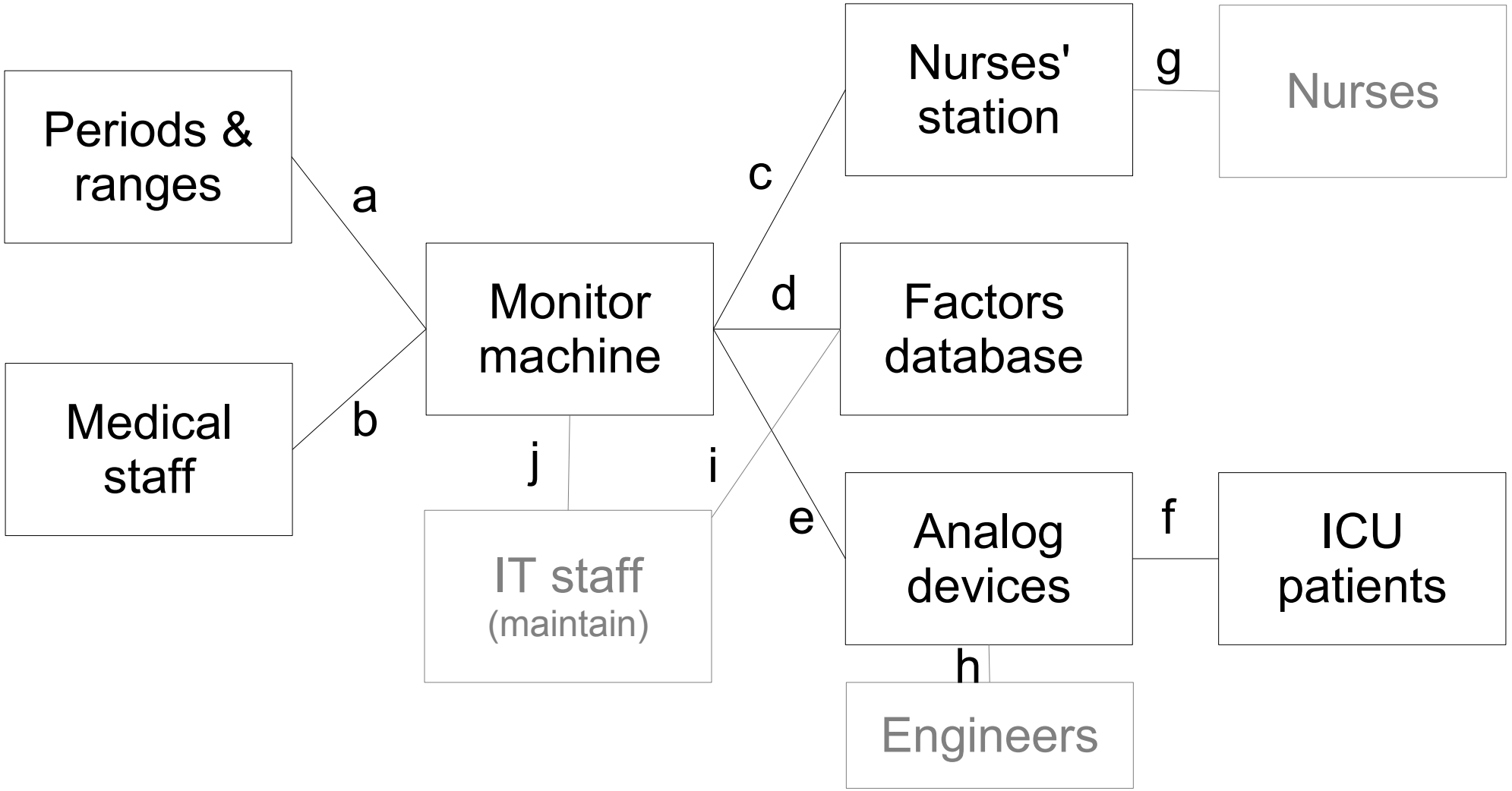

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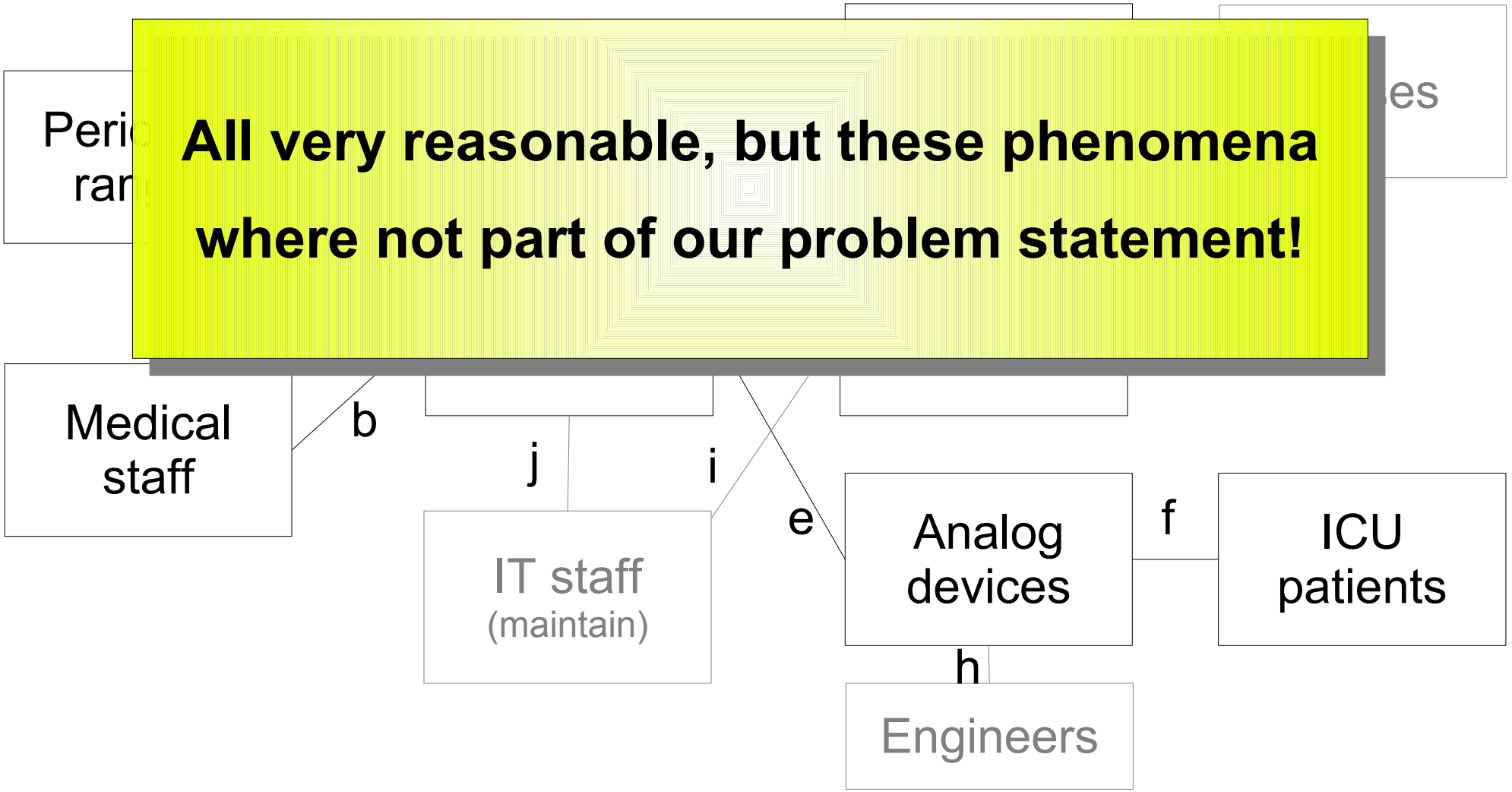

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Should they be?

Can we assume them?

Matter for more requirements elicitation and customer interaction

ICU patients