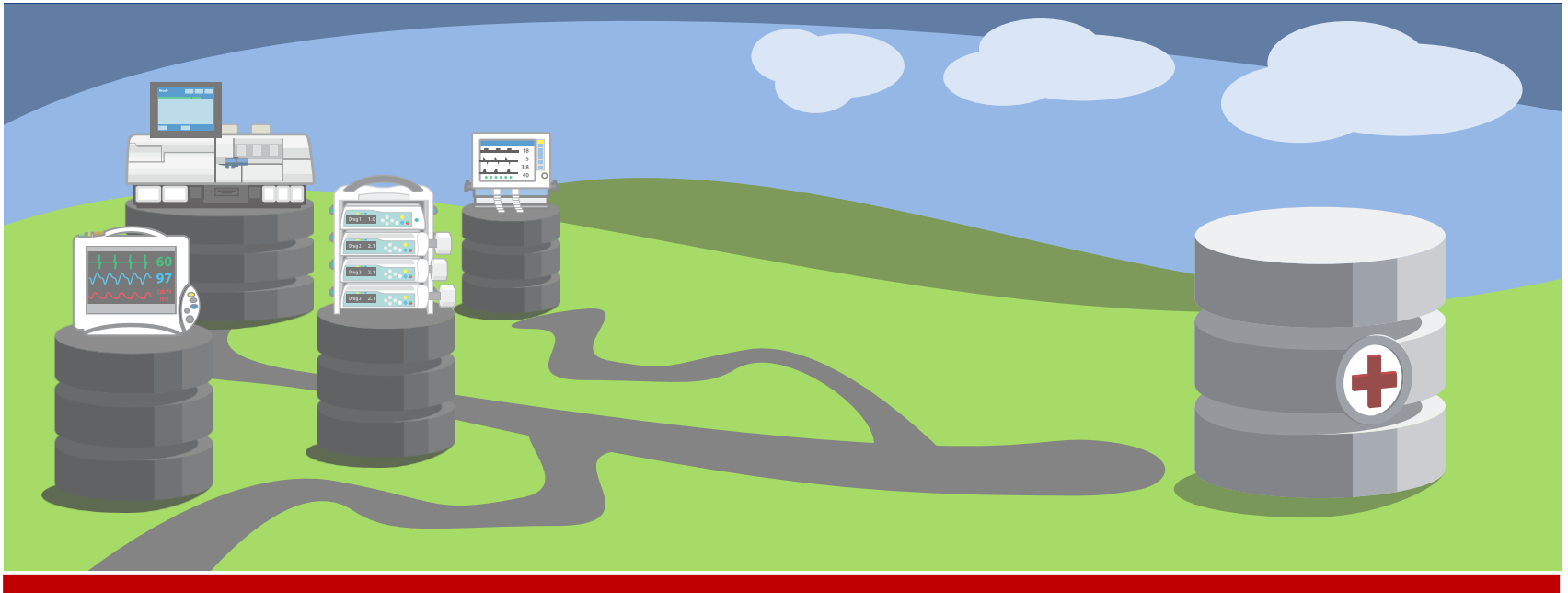




Data Integration

Dr. Jörg Peter



Theory

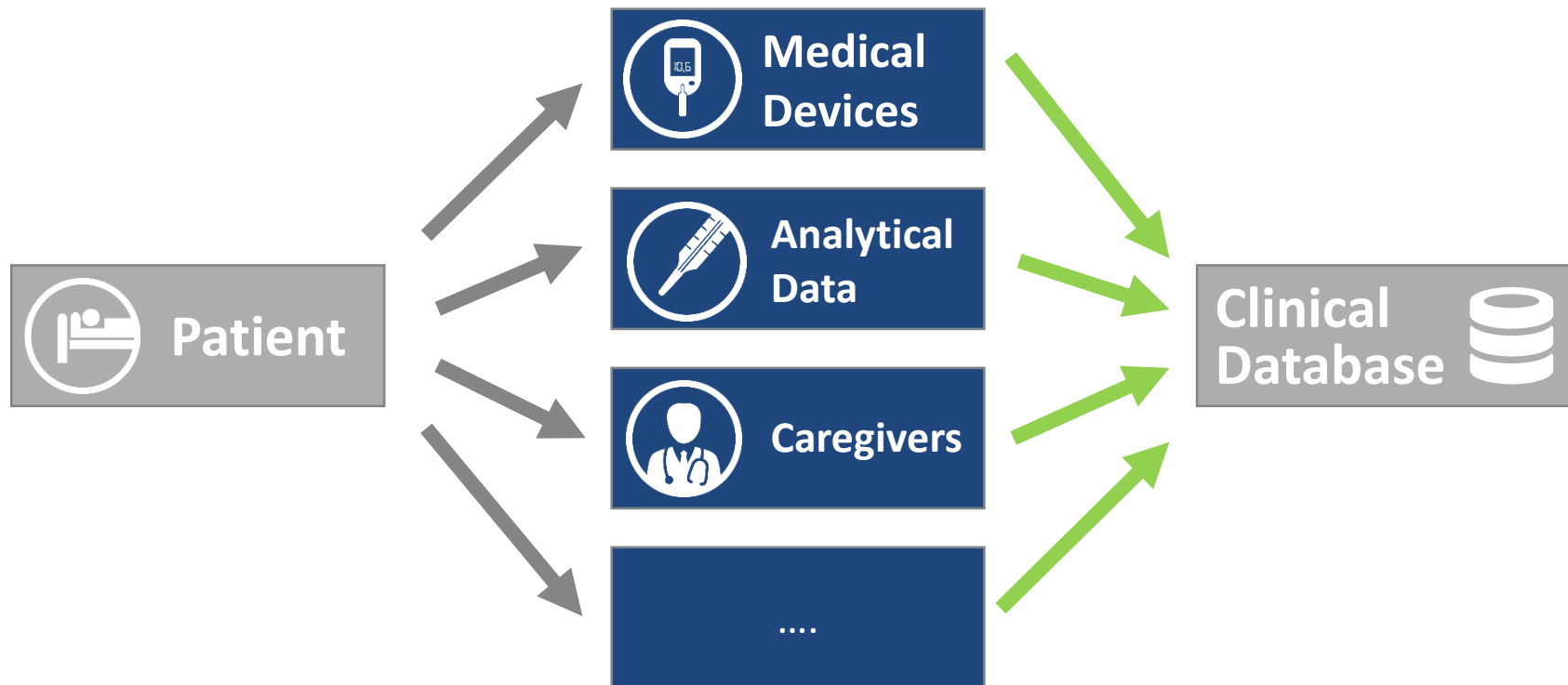
What is clinical data?



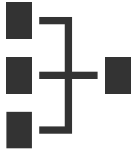
- Measurements from patient monitors
- Laboratory analyses
- Results of imaging procedures
- Caregivers' notes
- ...
- Genetic Data, Image Data
- Billing information

➔ **Complex & heterogenous information**

Collecting distributed data



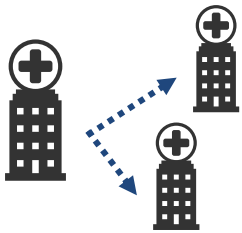
What needs to be done?



Data needs to be collected



Data needs to be stored



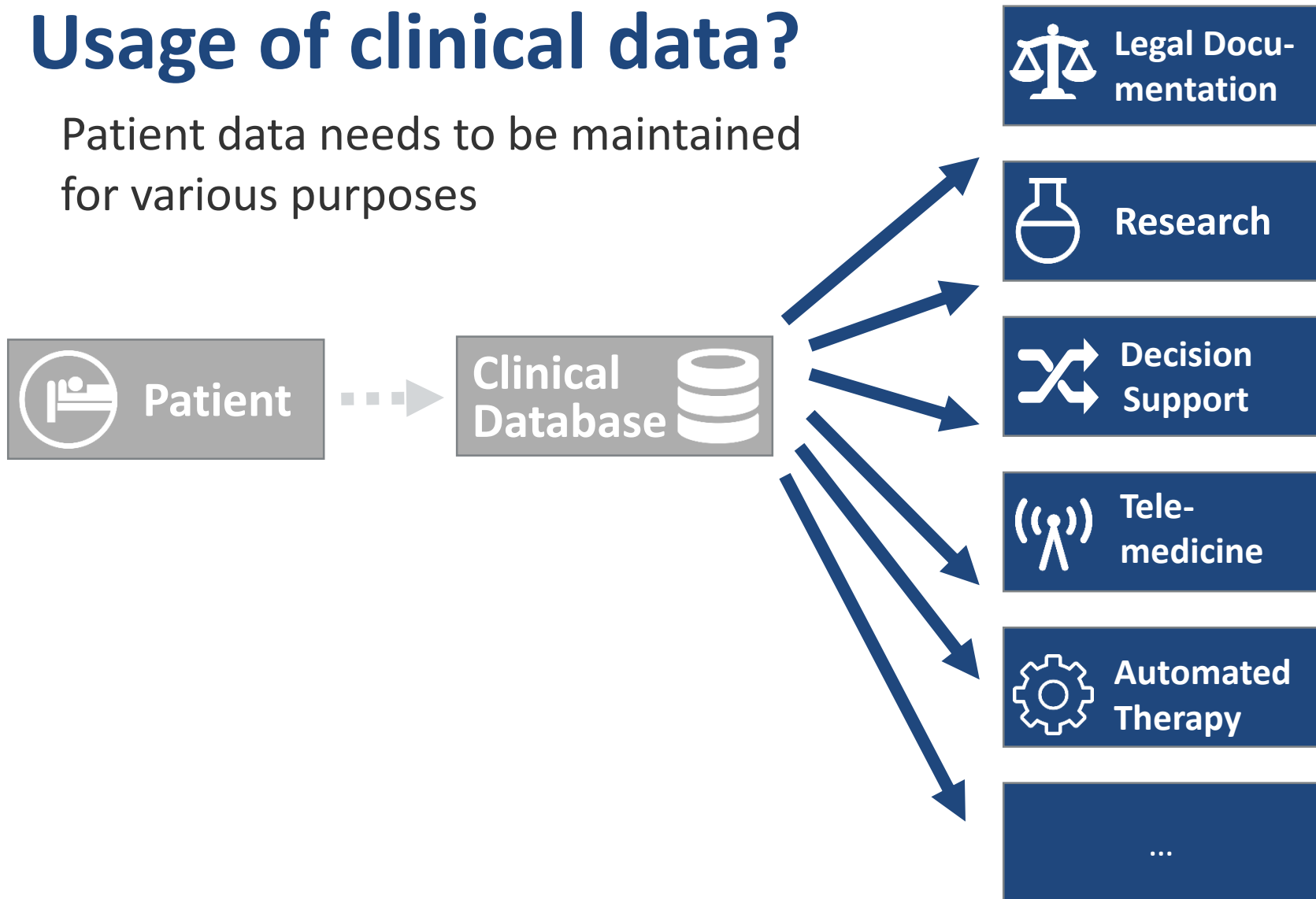
**May need to be transferred to
different departments / hospitals**

→ Automated data collection is important

→ Integration & processing required

Usage of clinical data?

Patient data needs to be maintained for various purposes



Importance of different data aspects

Highly dependent on the intended usage & further processing

	 Legal Documentation	 Clinical Decision Making	 Scientific Research
Data density	0	+	++
Data validity	+	++	0
Data availability	+	++	+
Data completeness	+	+	++



Decision Making requires precise real-time information

→ one of the most challenging topics for data integration

What is a database?



Organized collection of data



In the digital world:



System / software to store
& retrieve information



Often: relational databases

- **Interconnected tables**

ID	Name	Age
1	Doe, John	49
2	Mustermann, Max	37

ID	Pat. ID	Date	HR
1	1	2017-10-23 09:34	71
2	1	2017-10-23 19:12	68
3	2	2017-10-23 19:23	92

Clinical
Database



[By I. Saliko, CC BY-SA 3.0, <https://commons.wikimedia.org/w/index.php?curid=25095506>]

Patient Data - Patient record

Contains:



Patient information



Patient history



Measurements & procedures



Therapeutic notes

...



Paper record or digital version

00100110
01101010
10101101
11100111
01001011

Hand-written Paper record



UKT		SaO ₂																
O ₂			98	100	98	96	96	97	98	97	96	98	97	96	98	97	96	96
ZVD/mmHg			30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30
40 250			7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7
39 200																		
38 150																		
37 100																		
36 50																		
Temp. RR/P																		
BG		Bestm. form	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12
		Resp.-Frequ.	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13
		ETCO ₂	42	43	42	42	42	42	42	42	42	42	42	42	42	42	42	42
		MAP	94	94	94	94	94	94	94	94	94	94	94	94	94	94	94	94
		PAP	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
		Temp	36	36	36	36	36	36	36	36	36	36	36	36	36	36	36	36
Patientenlagerung (Re./Li./Rü./Bauch)		AVD	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12
Glucose (Stix) / mg%		HT	86	80	86	86	86	86	86	86	86	86	86	86	86	86	86	86
Systolic		Temp	36,0	36,2	35,8	36,1	36,7	36,2	36,4	36,7	36,6	36,7	36,5	36,2	36,3	36,3	36,3	36,3
TP1																		
TP2																		
Dornicum		10	10/25	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10
Fentanyl		10	10/25	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10
Cetamin		5	5/125	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
Arterio																		
Voluven			12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12
Kalic																		
Glucose			1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Larix			10mg	10mg	10mg	10mg	10mg	10mg	10mg	10mg	10mg	10mg	10mg	10mg	10mg	10mg	10mg	10mg
Nace			1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2
Locephon																		
Kalium			5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5

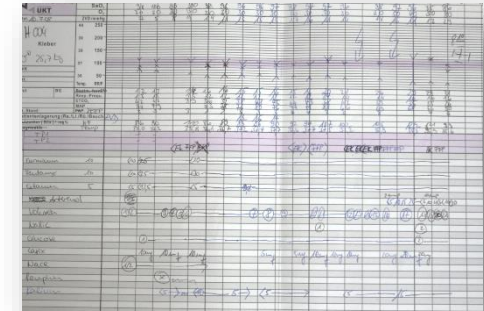
(Hand-written) paper record



Complex Information can be stored in tight space



But, however:



- **Not easily retrieved / single point of access**
 - Cannot be read by multiple users at the same time
 - Has to move with patient
 - If out of it's normal location
 - not accessible to caregivers
- **Data entries are sometimes illegible**
- **No further automated processing**

Electronic Health Record (EHR)

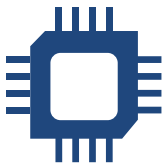
aka: Computer-based Patient Record (CPR)

Improve information storage & exchange



- Available to multiple users at the same time
- Timely access to patient data
- Combines past and current information about the patient
- Useful for building a clinical data repository

In integrated systems:



- Support clinical decision making
- Improve patient safety
- Promote quality improvement

Yet: Transfer between systems & departments often still performed manually / in paper form

Electronic Health Record (EHR)



- Strict specifications
- Precise information
- Limited complexity & freedom

Problem:

How to store additional & complex information?



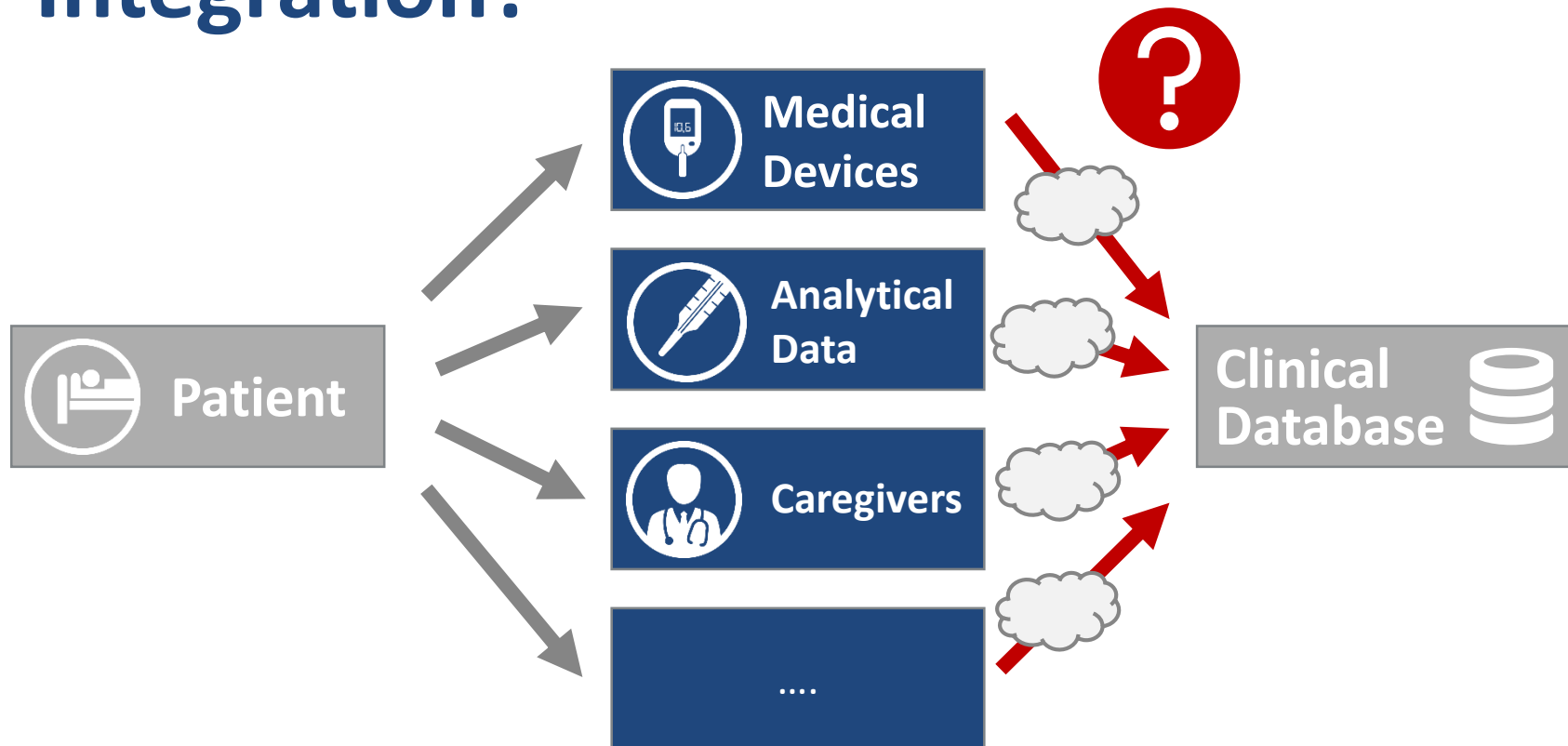
Can't find the correct field for entry?

→ **Free-text comments that can hardly be further processed**

Example for EPR guidelines and restrictions for input fields:

APP 065	Die Anzeige ist auf eine feste, systemweite Stellenanzahl begrenzt, längere Einträge sind markiert.
APP 066	In numerischen Feldern sind ausschließlich Zahlen erlaubt.
APP 067	Bei Datumeintragen erfolgt eine Formatkorrektur.
APP 068	Deutsche Datumsformate sind an jeder Stelle möglich.
APP 069	Datums- und Uhrzeiteingaben sind in verschiedenen Formaten (bei Freitextfeld) möglich (z.B. 15.4. -> 15.04.2012; 1234 -> 12:34, 12 -> 12:00)
APP 070	Die Auswahlfelder dienen der standardisierten Eintragung von Werten. Dazu werden Komboboxen oder einfache Wertelisten verwendet.
APP 071	Eine Mehrfachauswahl in Wertelisten ist möglich.
APP 072	Schlüsseltabellen der Auswahlfelder sind sortierbar und enthalten zum Wert eine Kurzbeschreibung.
APP 073	Werte in Schlüsseltabellen der Auswahlfelder sind durch Eingabe der ersten Buchstaben schnell auswählbar.
APP 074	Werte aus Schlüsseltabellen der Auswahlfelder werden mit einem spezifischen Filter angeboten z.B. Stations.- oder altersspezifisch.
APP 075	Eine Vorbelegung von Eingabeobjekten durch Defaultwerte ist möglich (diese müssen stationsspezifisch individuell einstellbar sein).
APP 076	Zur Anzeige in Sichten müssen Eintragungen mit Symbolen hinterlegt werden können (insbesondere in der Narkosedokumentation), die anstatt des Wertes angezeigt werden.

How to perform data collection & Integration?



Automated processing & interconnection



Why? / Advantages?



- No need for manual entry
- Less human resource-intensive



- More accurate
- More reliable



- Higher frequency (not so often entered manually)



- Time-critical information is transferred faster

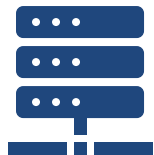
Information systems

Require:



- Data collection
- Data storage (Database)
- Data reporting / presentation
- Communication
- Interconnection

Different system types:



- Departement-based
- Information-source based
- Administrative
- ...

Theory

EHR System

Includes:



- Data entry
- Storage
- Presentation (access to clinical decision maker)

Entry:



- Keyboard, dictation, transcription, voice recognition, touchscreen, hand-held systems
- Direct instrumentation from medical devices, barcodes, RFID, laboratory analyzers, ICU monitors

Presentation:



- Text, tables, graphs, sound, images, video
- Electronic, paper

Clinical Decision Support Systems (CDDS)



Computer software to aid clinical decision making

Provide caregiver with medical knowledge



- Diagnostic suggestions
- Testing prompts
- Therapeutic protocols
- Guidelines
- Alerts
- ...



Administrative systems

Financial system

Other systems

Patient Records Decision Support

**entity of all
integrated
systems**

Hospital Information System (HIS)



Clinical Information Systems (CIS)

ICU system Respiratory
 care system Nursing
 system



Departmental Systems

Pharmacy system Radiology system

Limited scope

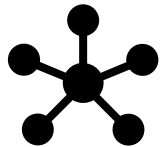
- One-dimensional
- Focus on individual aspects

Isolated deployment

- Specific needs of individual units

Theory

System interconnection



Interconnection required for full EHR & HIS



Systems need to exchange information

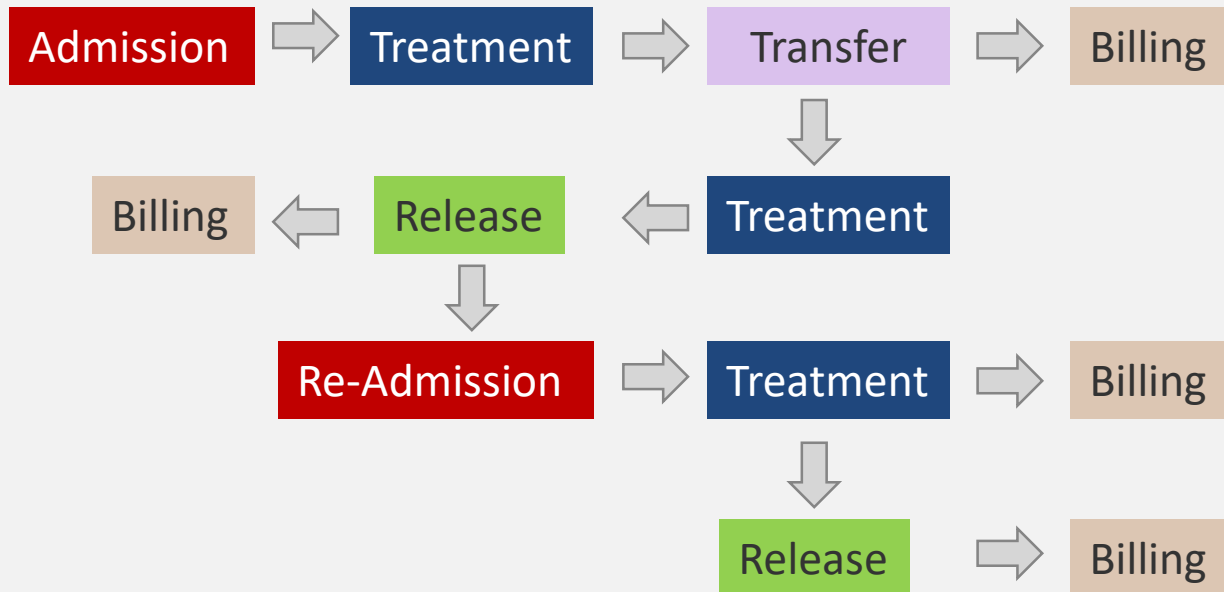


have a universal „language“ or translations

- aka: understand each other
- Coding standards

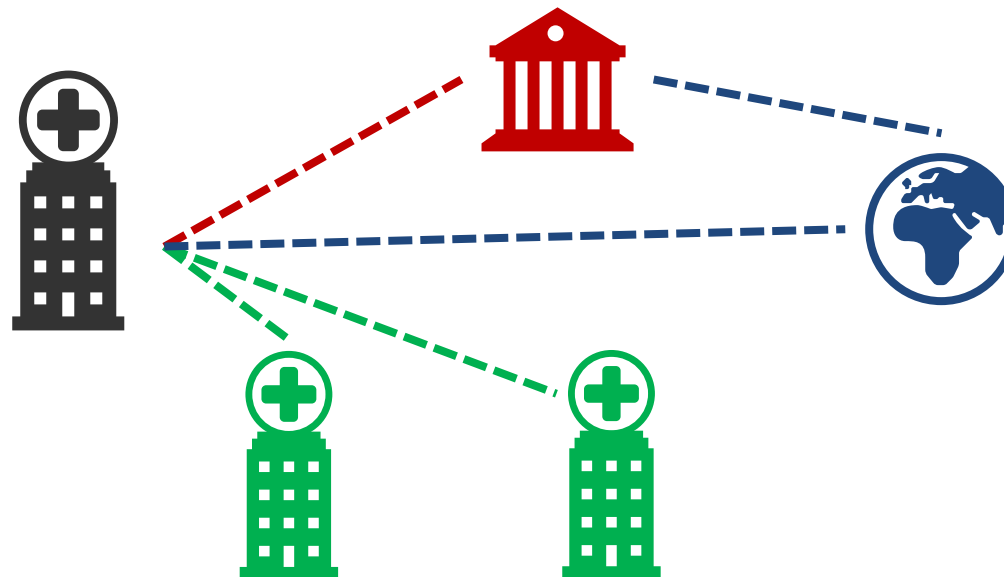
Theory

Complex interactions



Further integration layers

- Interaction between hospitals
- Interaction with healthcare insurers & government
- Other national and international levels



Reality

The challenges of data collection & integration



[[https://de.wikipedia.org/wiki/Turmbau_zu_Babel_\(Bruegel\)](https://de.wikipedia.org/wiki/Turmbau_zu_Babel_(Bruegel))]

Compartmentalization



Various types of measurements

- Real-time patient monitoring
- Laboratory & POC data (blood samples)
- Billing, diagnostic & procedure codes
- Imaging results
- Genomics & proteomics data



Individual systems, no universal HIS

Numerous devices / screens / interfaces

- distributed, compartmented information

Data processing & storage



Number of electronic devices steadily increasing



Various individual systems

- Clinical information systems
- Electronic patient record
- Departemental systems
- ...

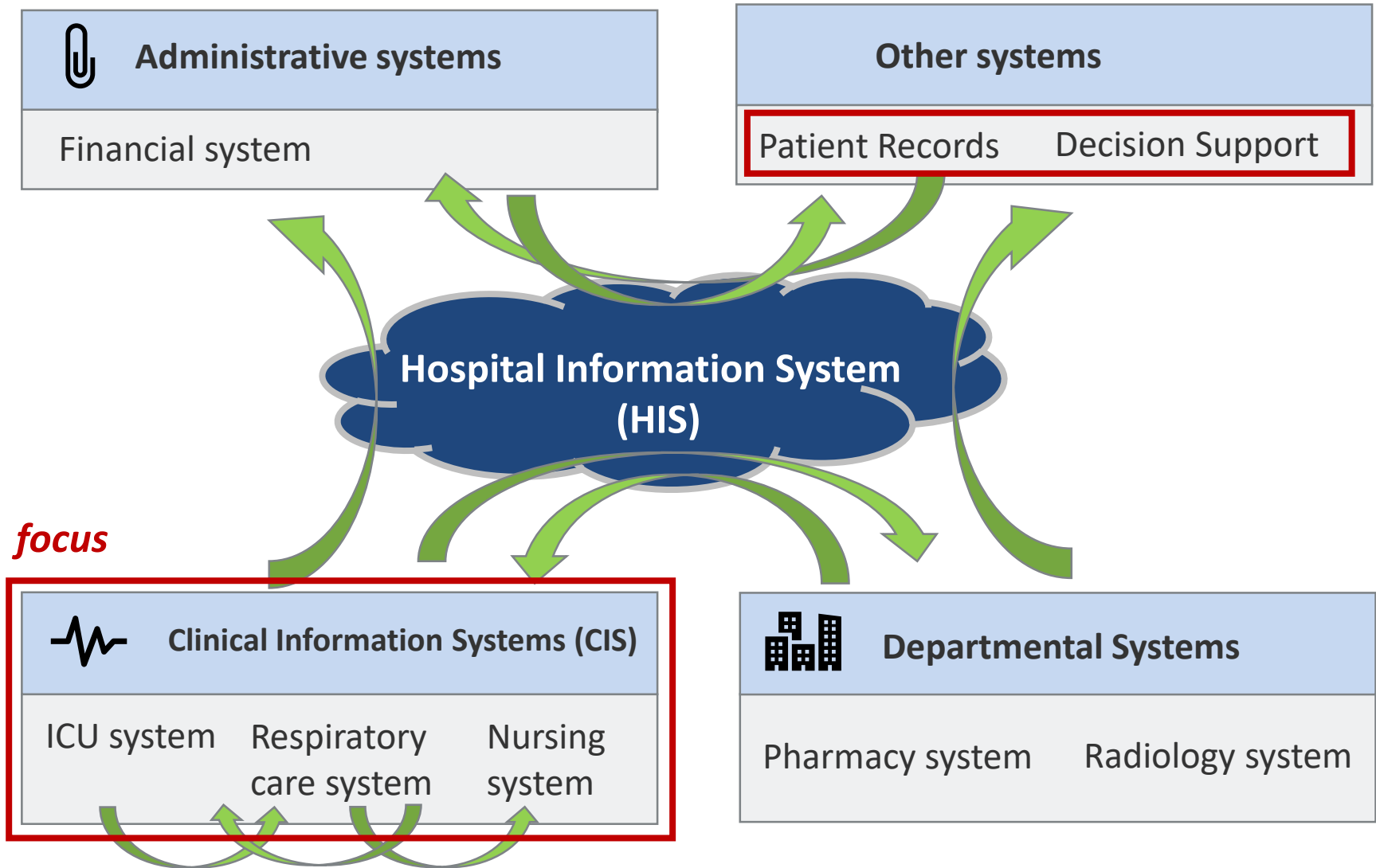


Mostly Independent

- Loose interconnections
- Limited export options
- Interconnection requires conversions between different data formats

Challenges

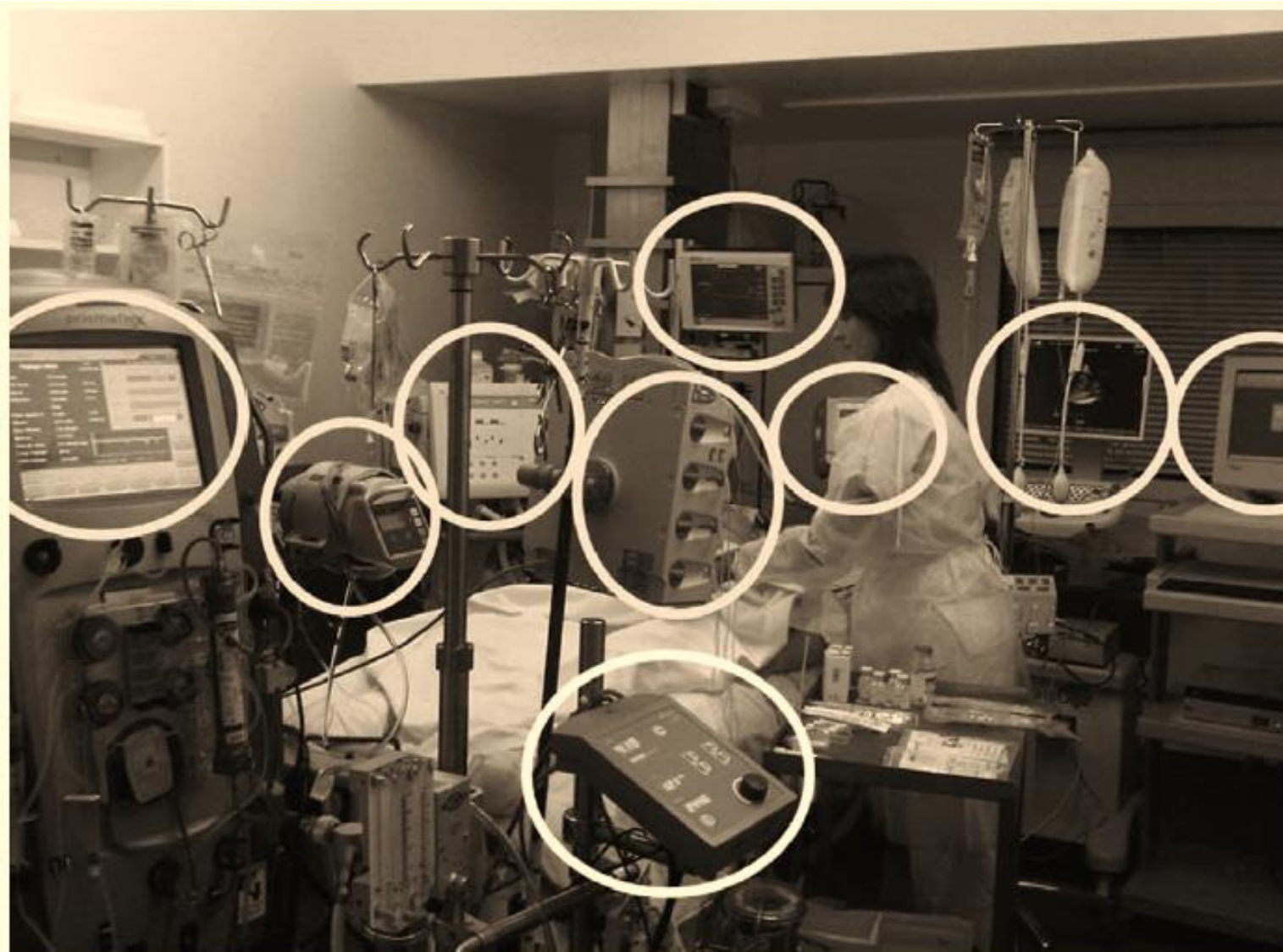
Translation tables to map information from one system to another
(often high maintenance efforts required)



Challenges



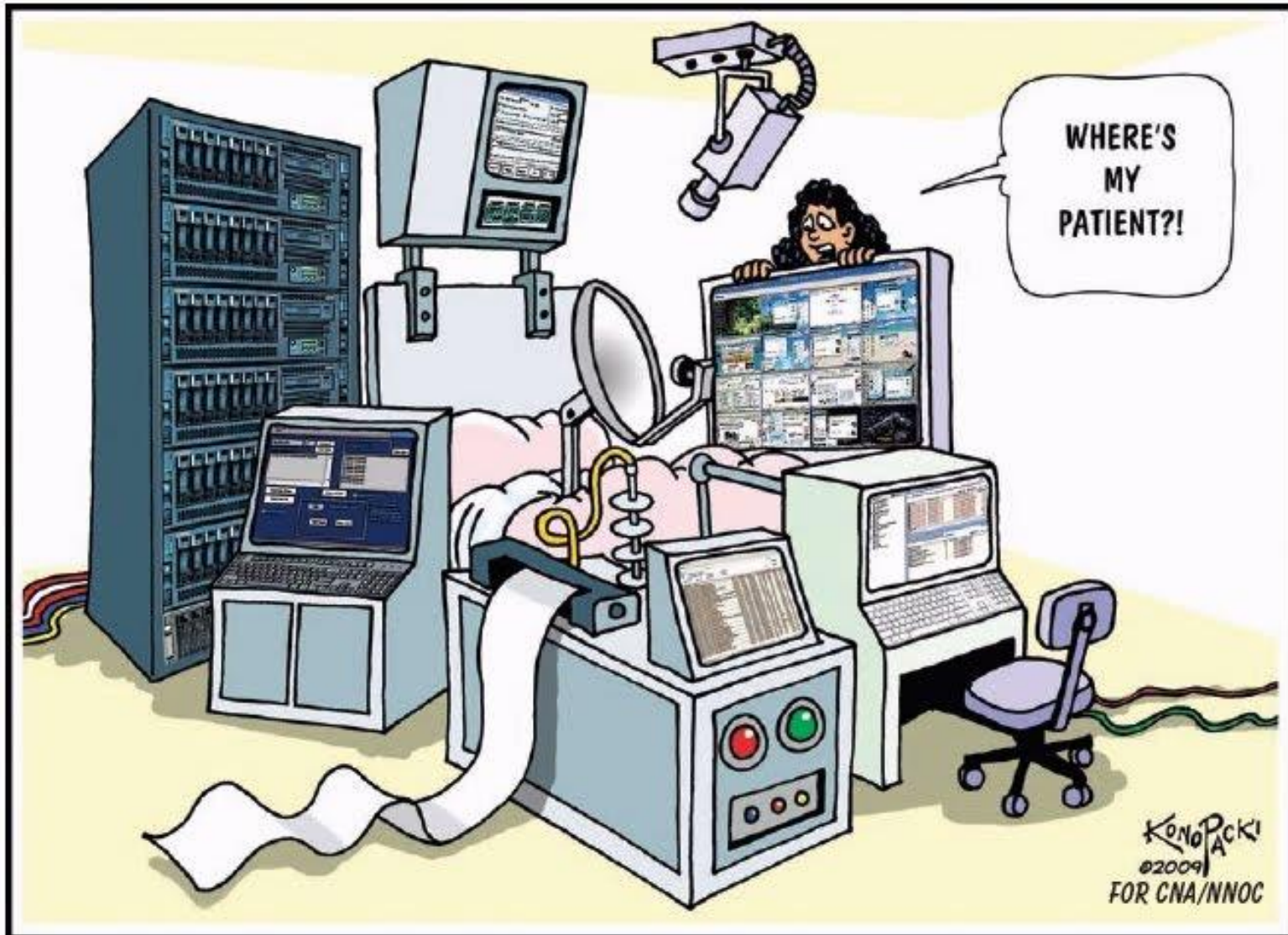
Various medical devices & interfaces



Modified from: Crit Care Med. 2016;44(2):386-9 The Future of
Critical Care Medicine: Integration and Personalization. Vincent JL.

Challenges

In other words:



Challenges

Various medical devices



Intensive Monitoring
Ventilator
Infusion Pumps
Point-of-Care Monitoring
Blood Gas Analyzer
Blood Coagulation Monitoring

Neuro-Monitoring
Life-Support Devices
Dialysis
Clinical Lab
(Image-based Information)



Challenges

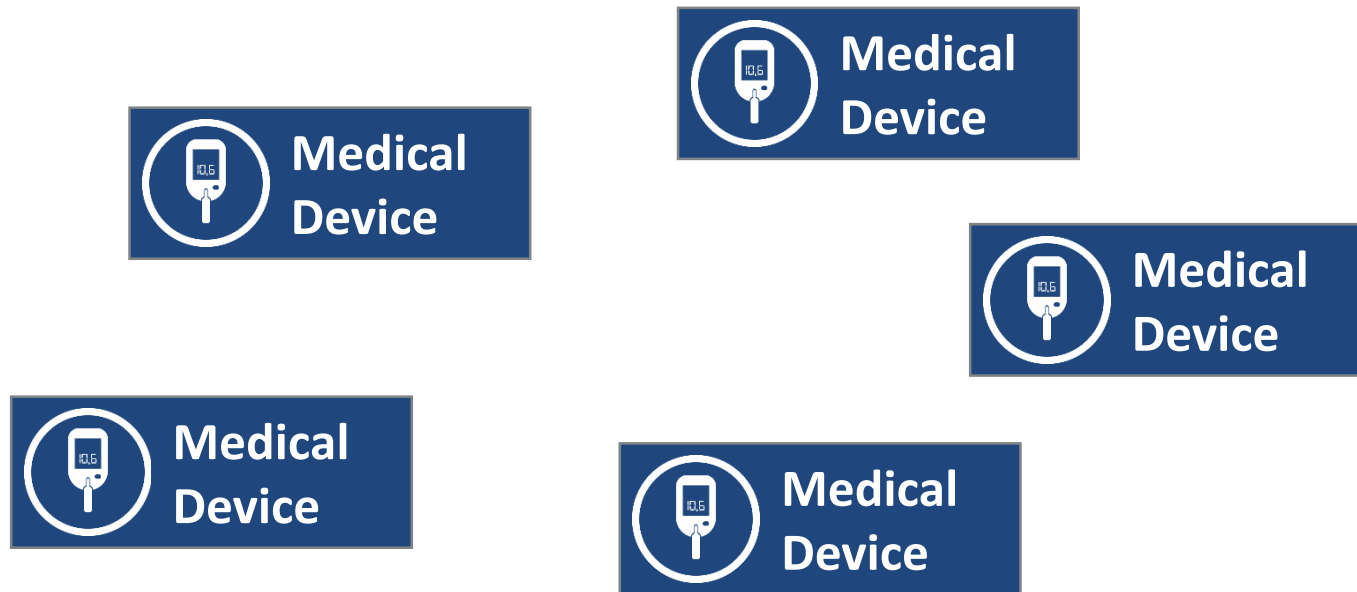


Compartmentalization & heterogenous landscape

Challenges

Heterogenous landscape

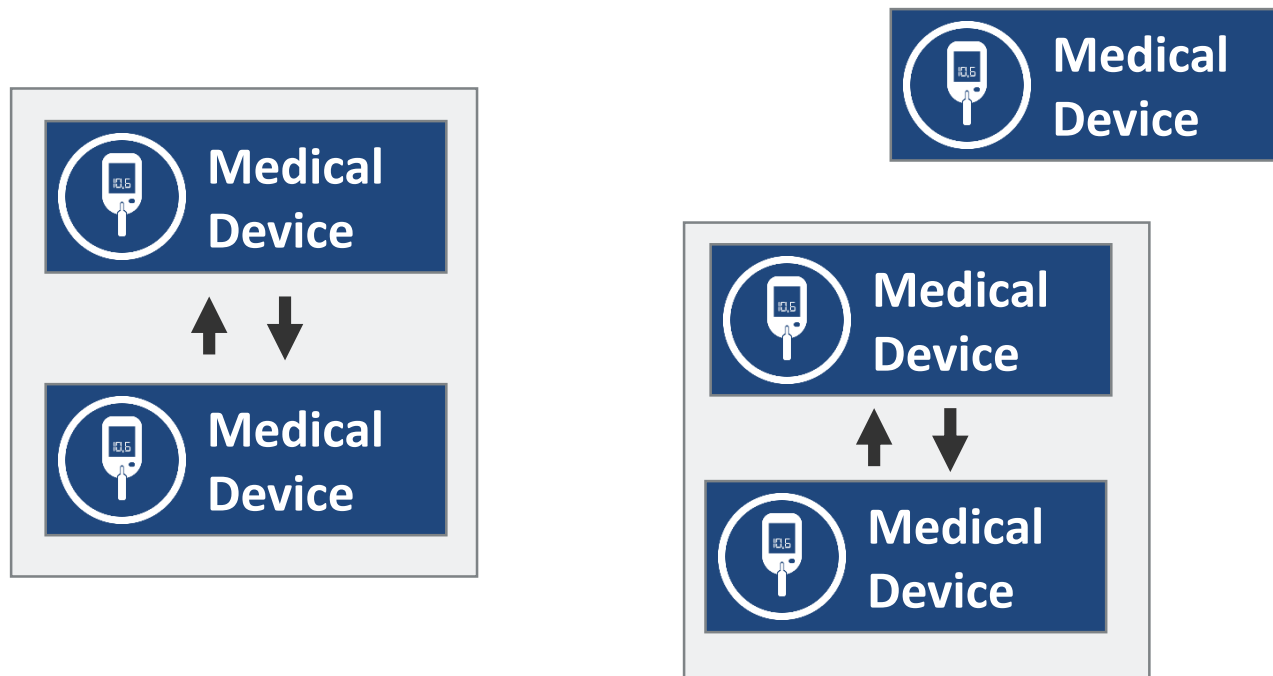
- Devices developed independently



Challenges

Heterogenous landscape

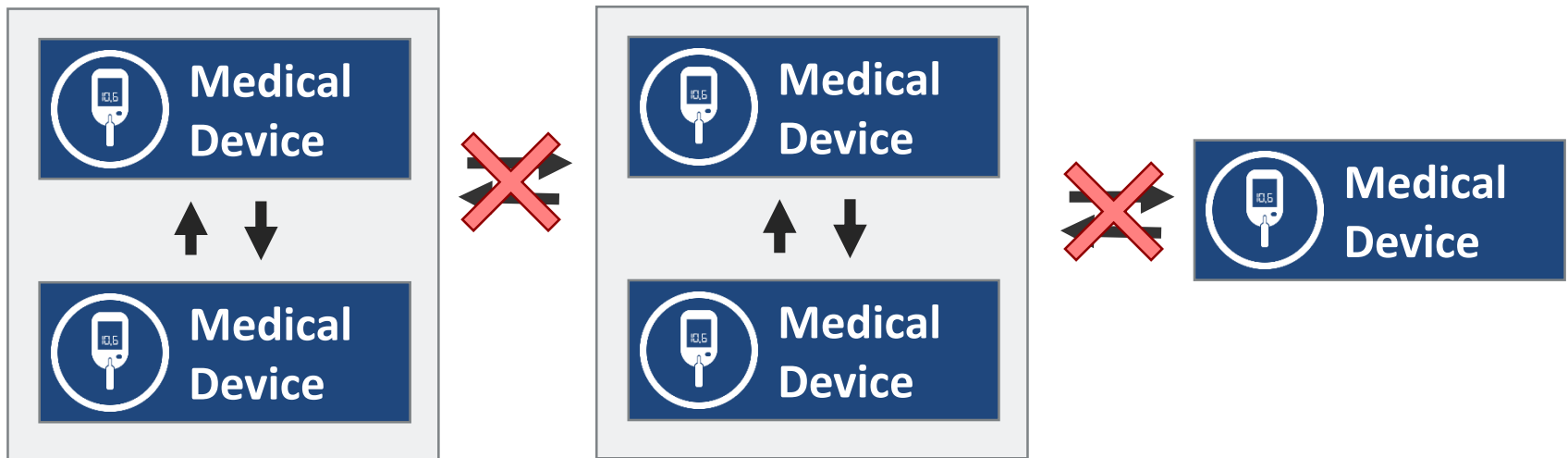
- Devices developed independently
- Different manufacturers



Challenges

Heterogenous landscape

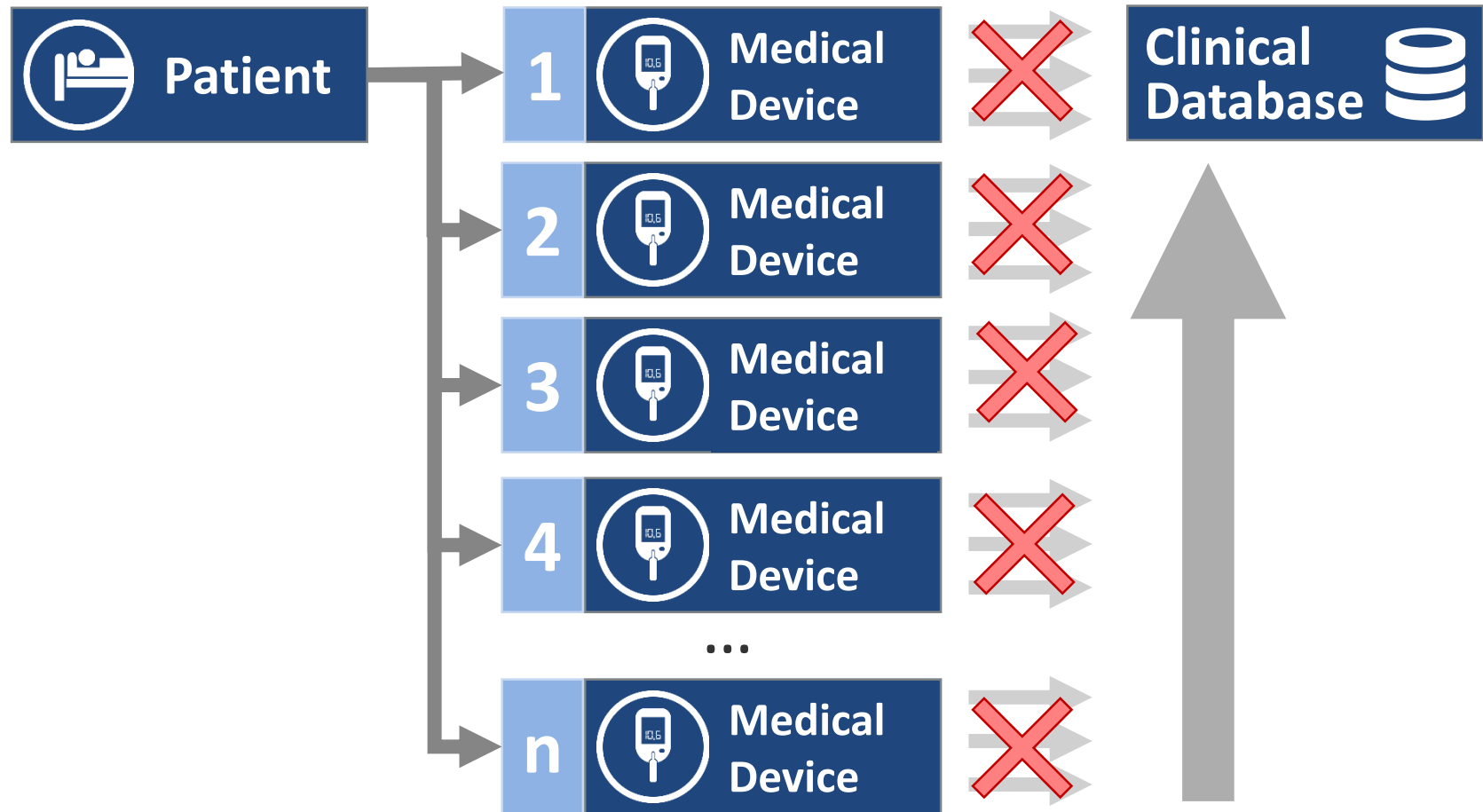
- Devices developed independently
 - Different manufacturers
- limited or missing compatability
- various device clusters



Challenges

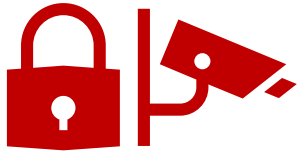
Heterogenous landscape

Result: **limited interconnection**



Challenges

Privacy & Security



How to ensure privacy and security of patient data in centralized storages?

→ Pseudonymize / Anonymize data



Structured Data?

→ Process fields / mask them / random IDs



Unstructured Data / Physician's letters?

→ Text Parsing / Data Mining?



**Large-Volume Data? Images?
Genomics? Proteomics?**

Harmony & semantic integration

– *Equal but different*

Same Entity, different encodings:



- Different terms
- Different units (2ml/h , 48ml daily, ...)



Even more complex with textual input:

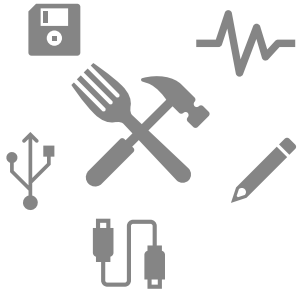
Same Meanings, but different wording:

Non-smoker , *smoker*: - , *no tobacco* , ...





Compartmentalization & heterogenous landscape



- Complex Information
- Numerous different devices, standards, formats & protocols
- Security & privacy concerns
- Data harmonization



Corruption & Availability

Challenges

Limited availability of data



No standard can help if data isn't collected or available

Examples for missing interconnection and experimental solutions at the Schenk Lab to be presented:

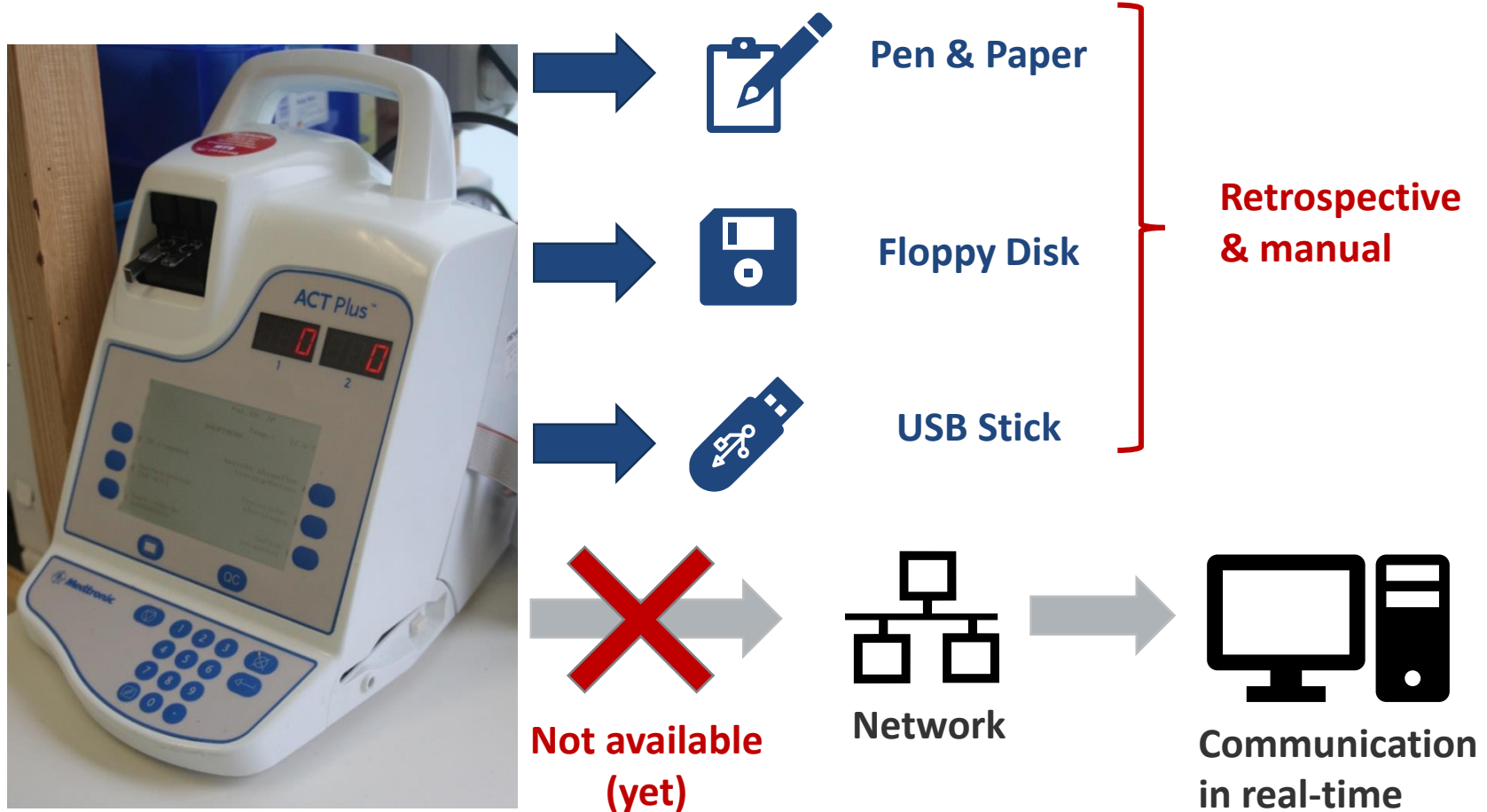


- Clotting time measurements
- Diuresis assessment

Challenges

Problem: Availability of data

Example 1: Point-of-care ACT measurement



Challenges

Problem: Availability of data

Example 2: Diuresis Measurement



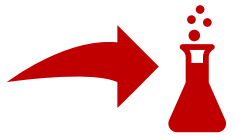
Collected urine?



**Manual reading
& notation for
patient record**



Data most often collected to guide caregivers & document clinical activity for reporting, liability, and billing reasons



But not: to facilitate analysis & research (*„secondary“ use*)

Automatically collected data must be handled with care!

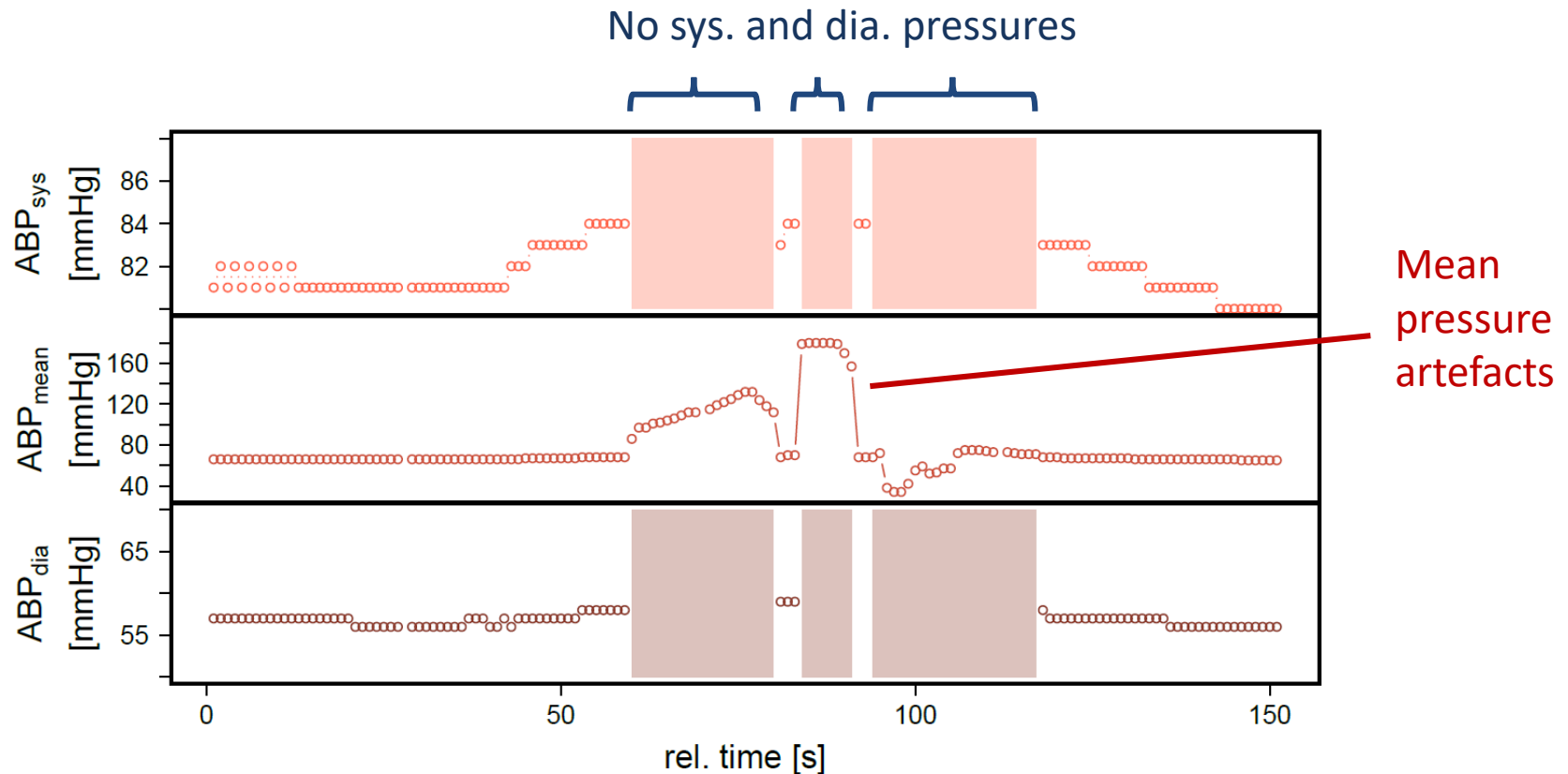
- Missing, erroneous & imprecise data

Example: sensor corruption

- Sensor drop-offs
- Artifacts
- Treatment interventions
- Incomplete measurements

Example: Artifacts & missing data

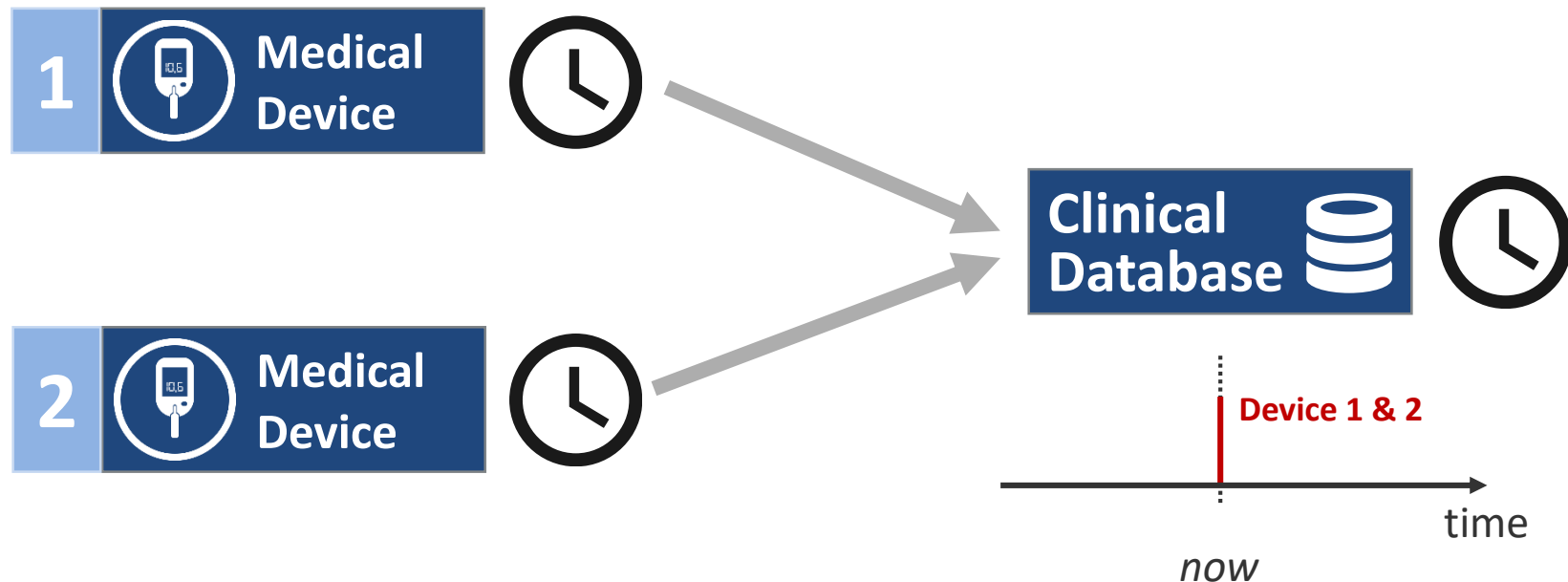
Arterial pressures during blood withdrawal from same access (three-way tap)



Challenges

Example: Data registration

Data from different sources needs to be matched to each other in the time domain

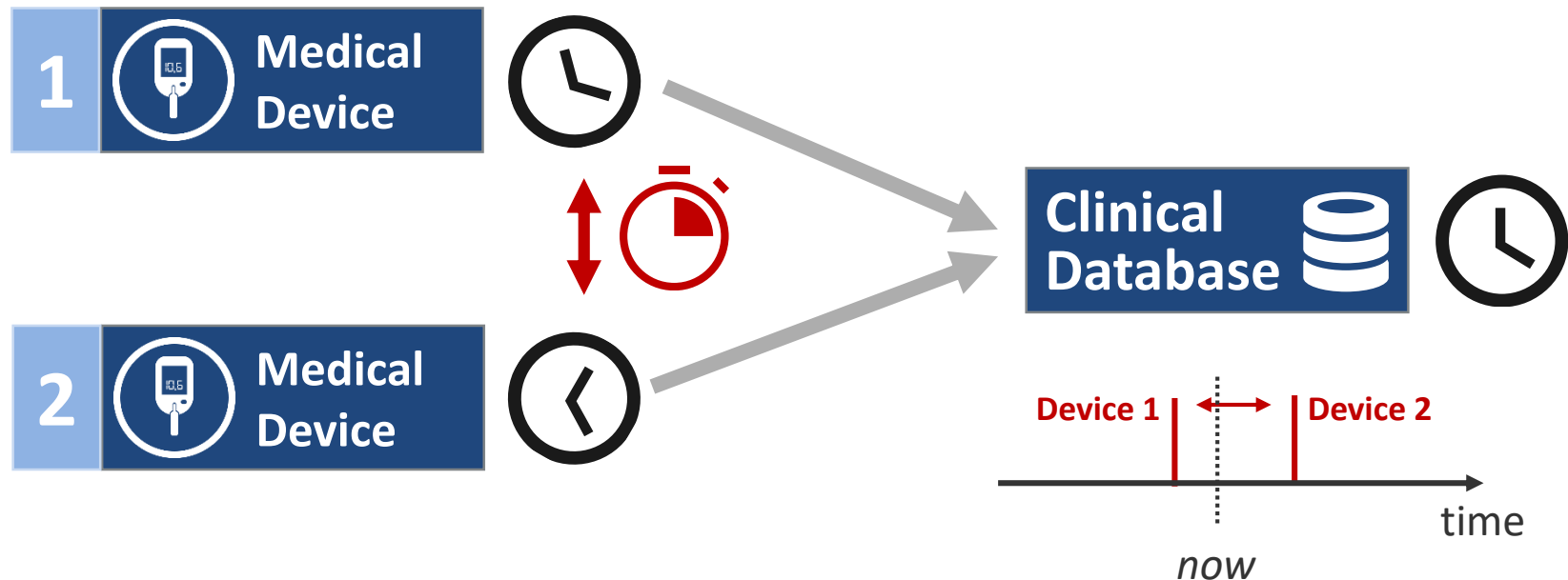


Challenges

Example: Data registration

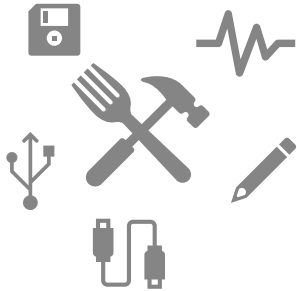
Data from different sources needs to be matched to each other in the time domain

**Problem for time-critical applications
& high-resolution data**





Compartmentalization & heterogenous landscape



- Complex Information
- Numerous different devices, standards, formats & protocols
- Security & privacy concerns
- Data harmonization



Corruption & Availability

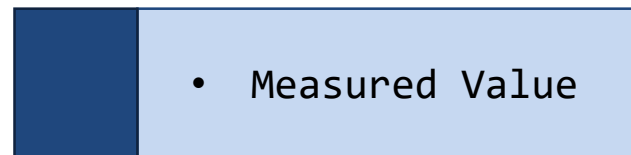
- Limited reliability
- Limited availability



Complexity & Storage

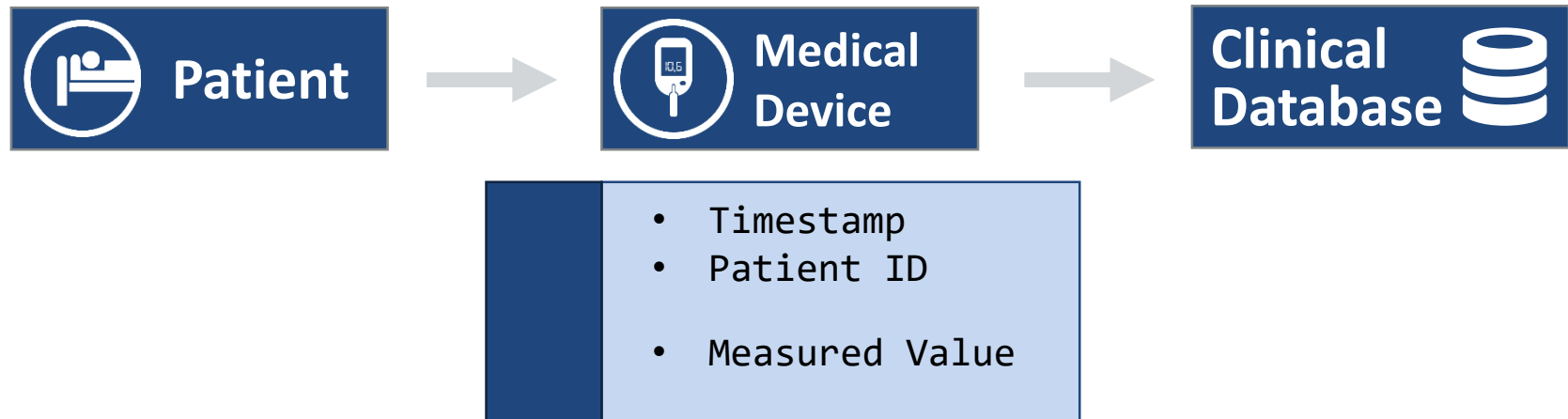
Challenges

Data variety & complexity



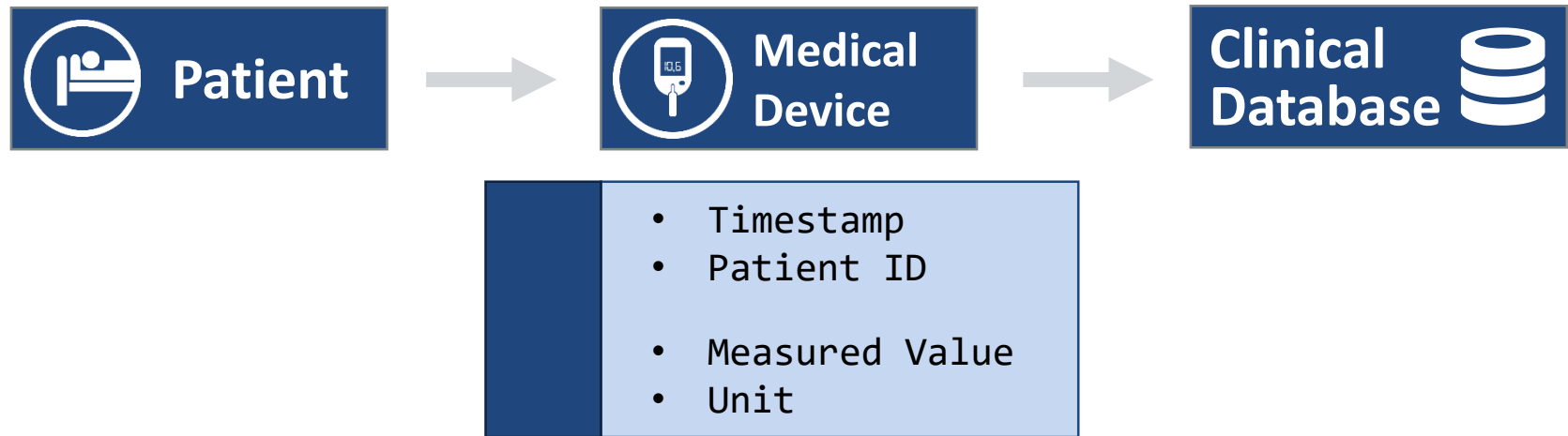
Challenges

Data variety & complexity



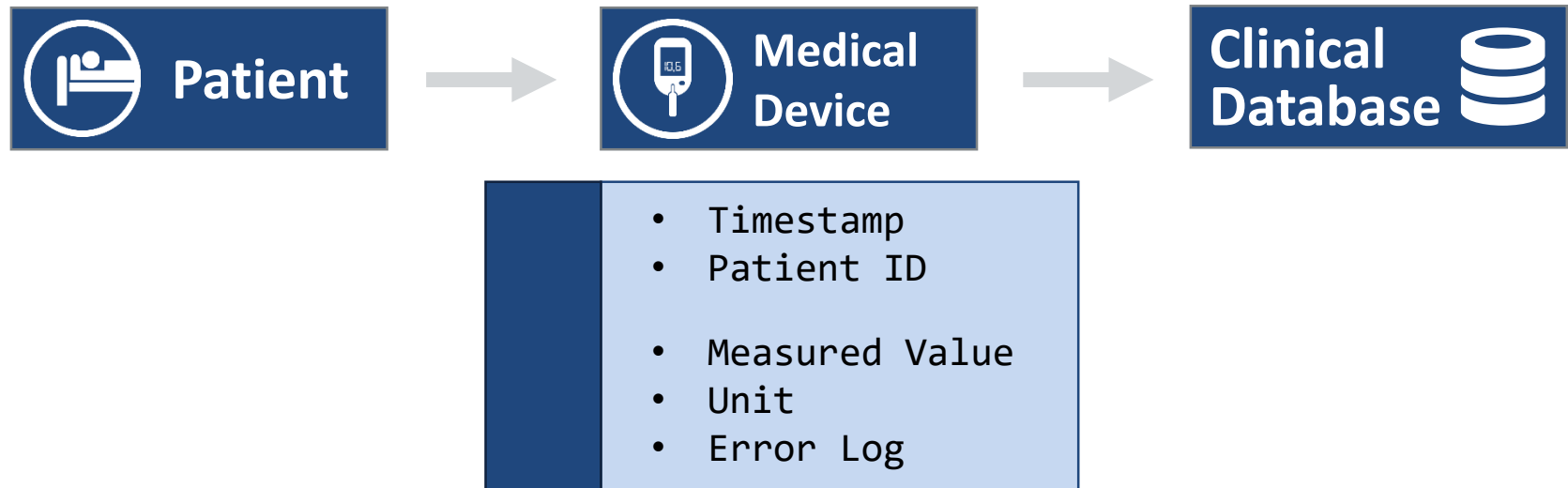
Challenges

Data variety & complexity



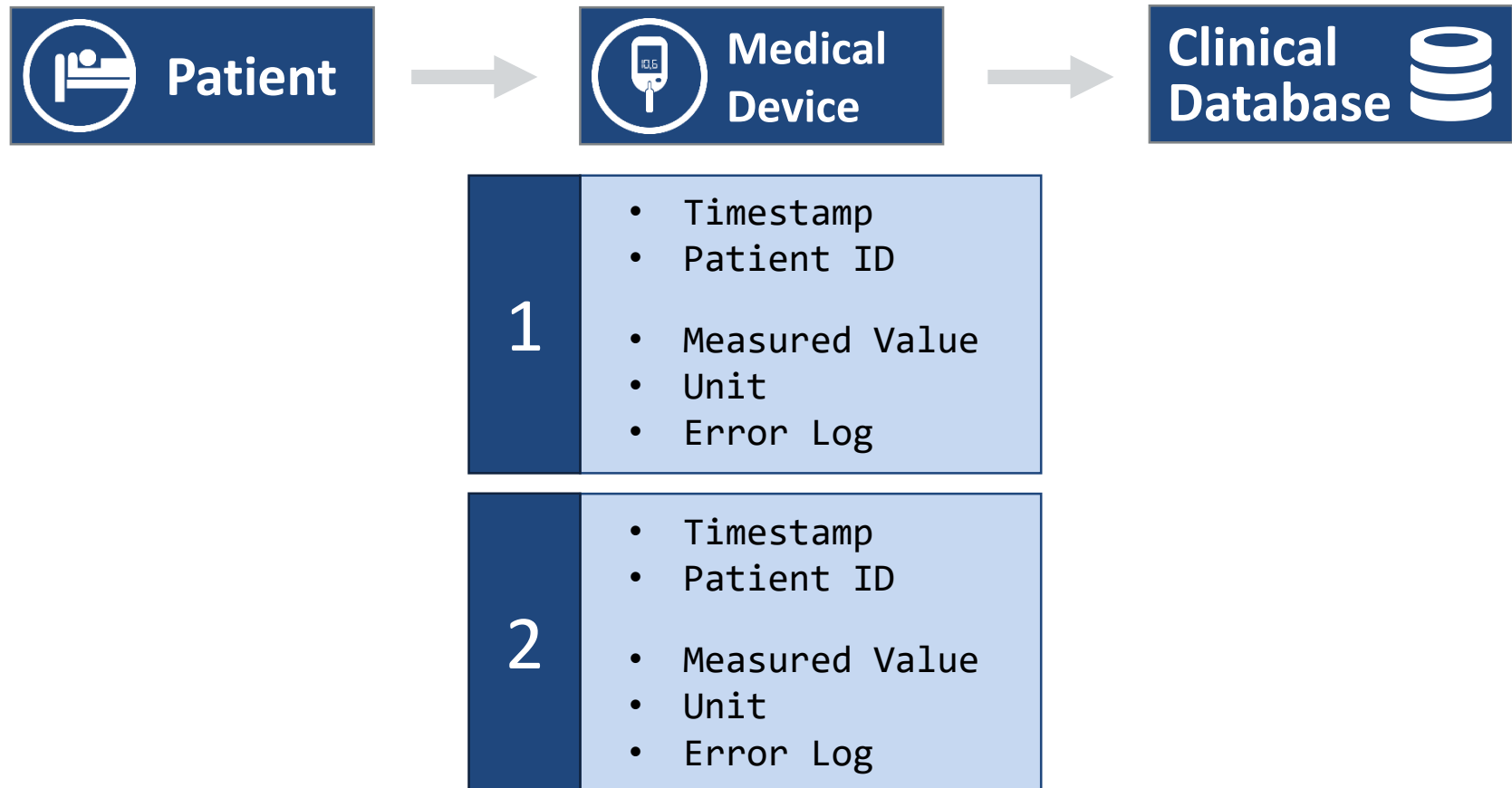
Challenges

Data variety & complexity



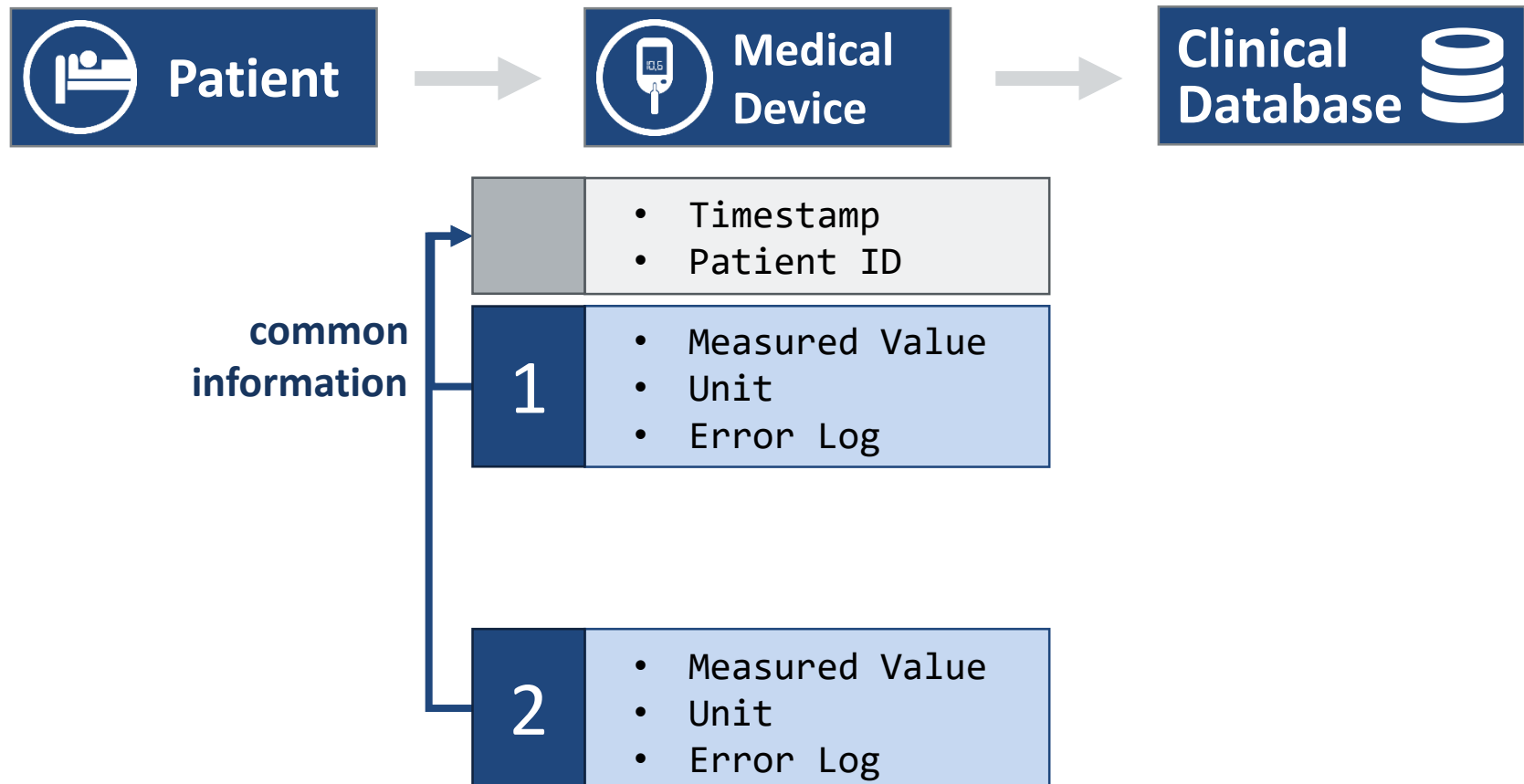
Challenges

Data variety & complexity



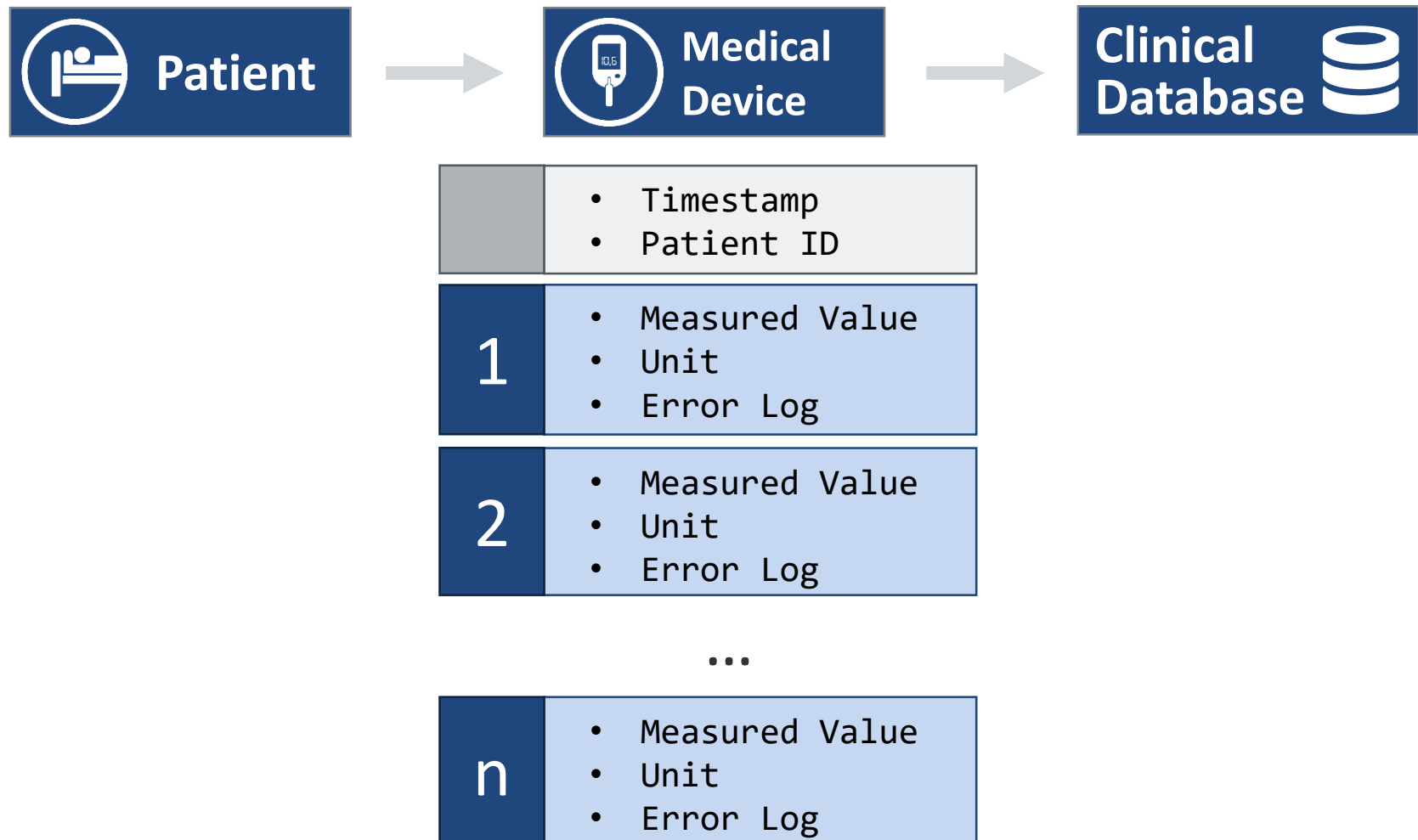
Challenges

Data variety & complexity



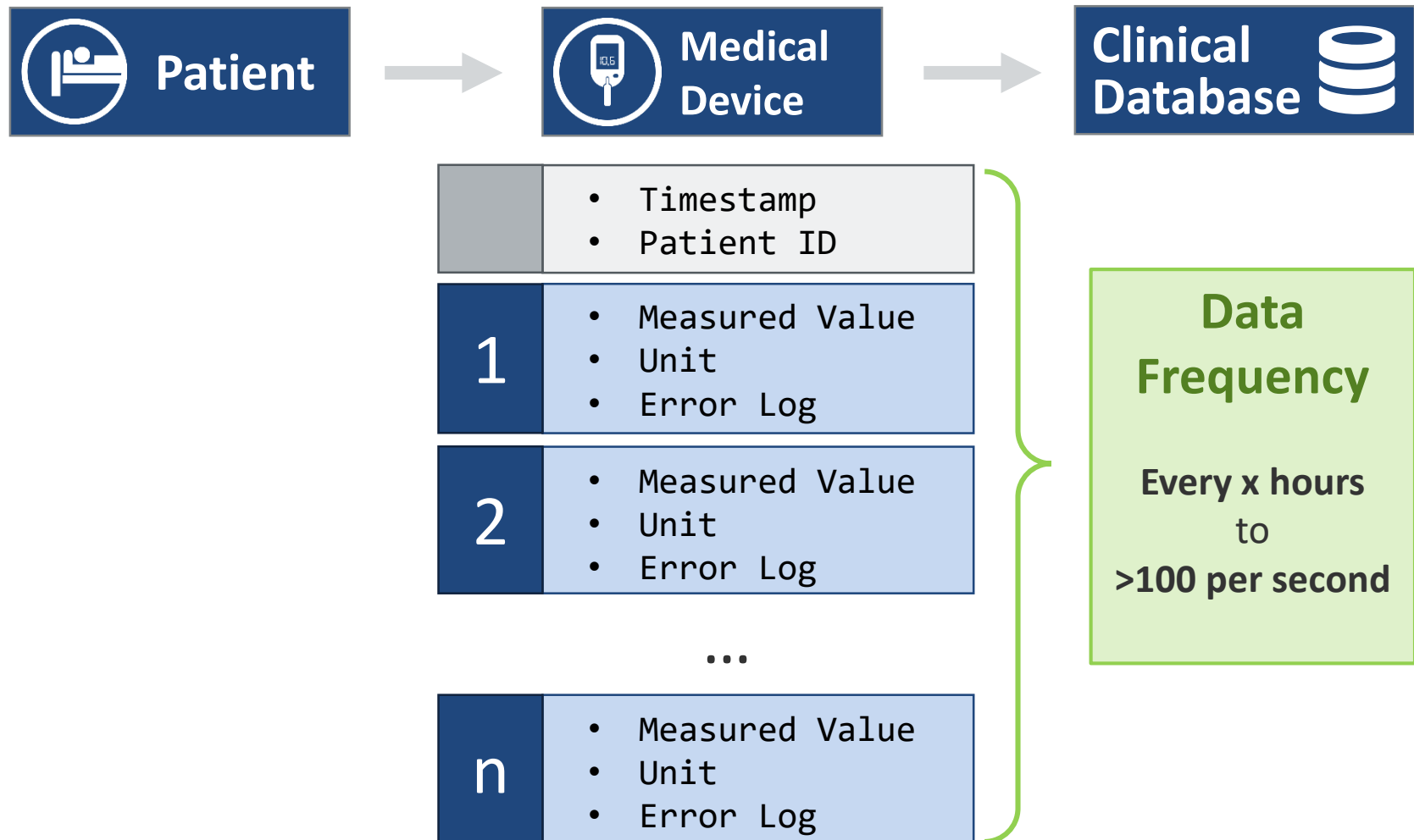
Challenges

Data variety & complexity



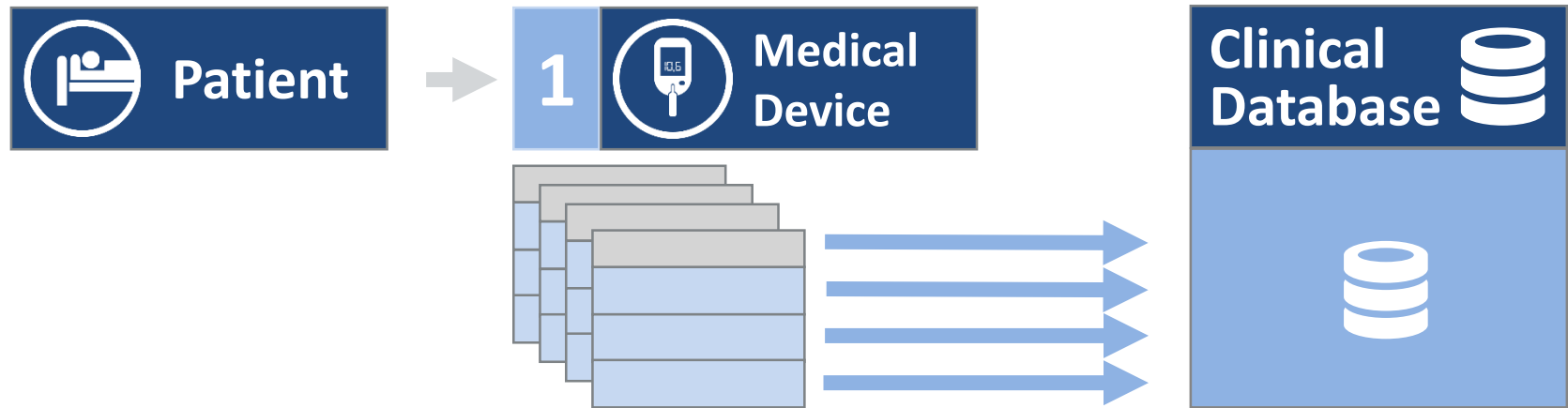
Challenges

Data variety & complexity



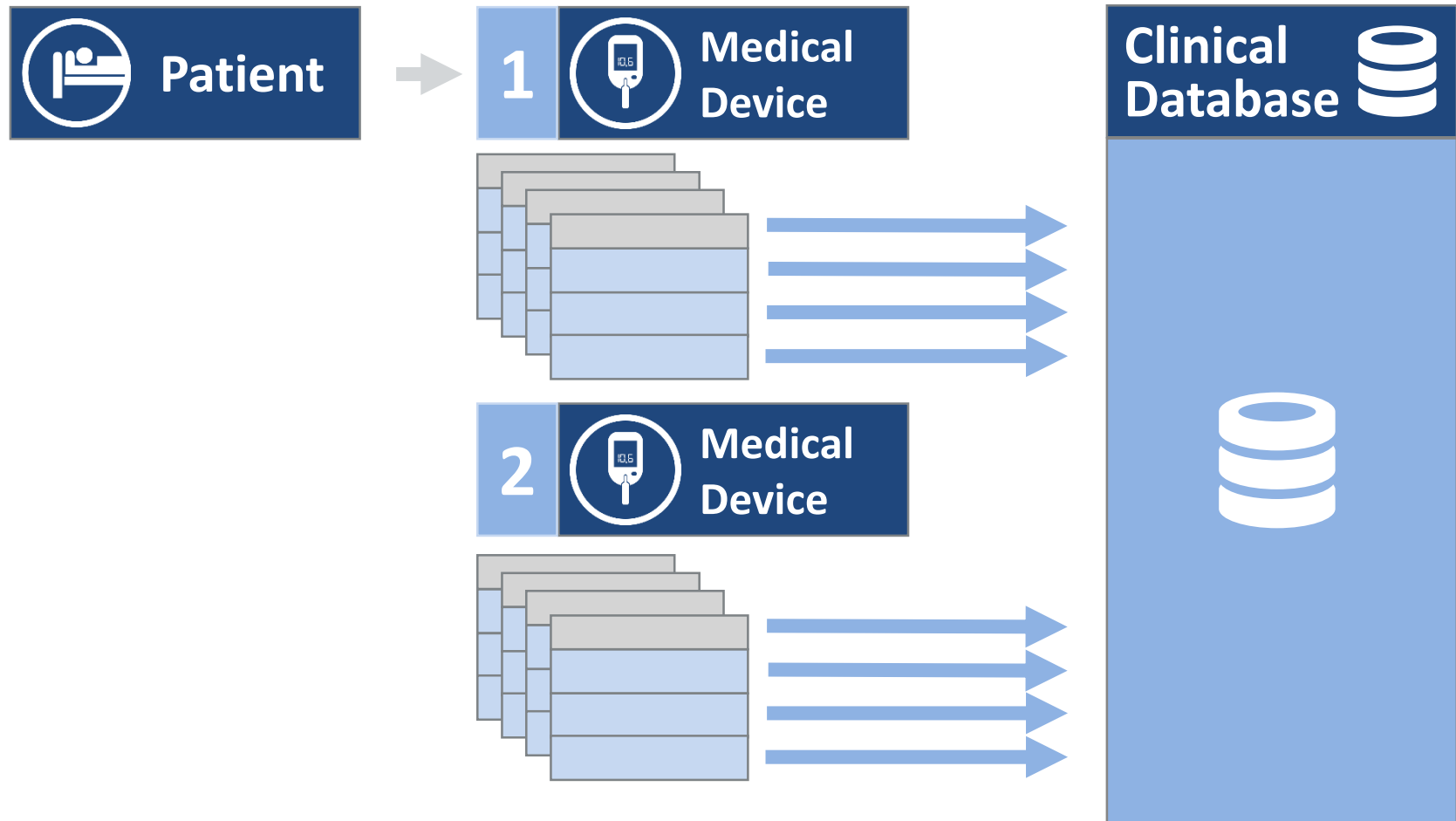
Challenges

Data variety & complexity



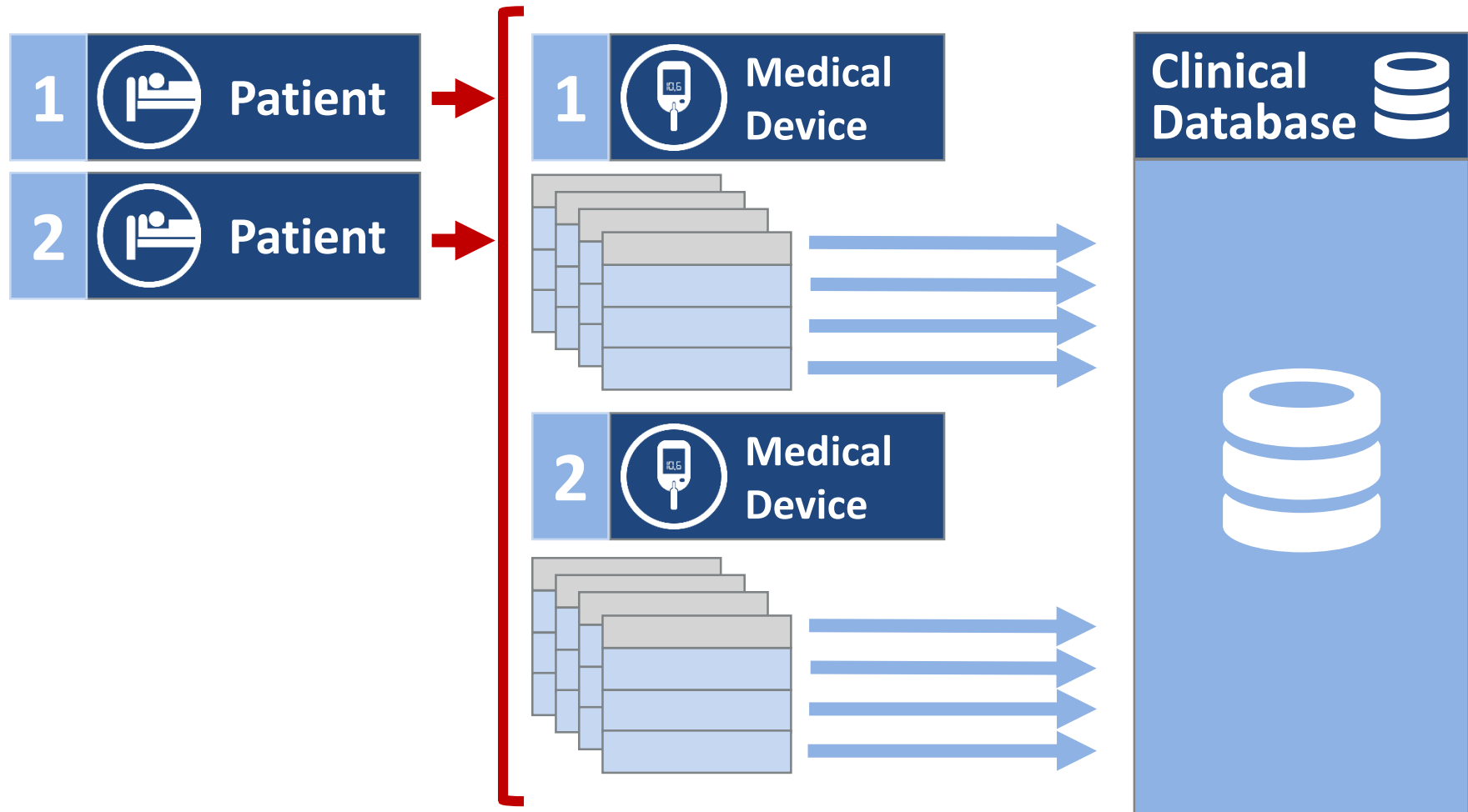
Challenges

Data variety & complexity



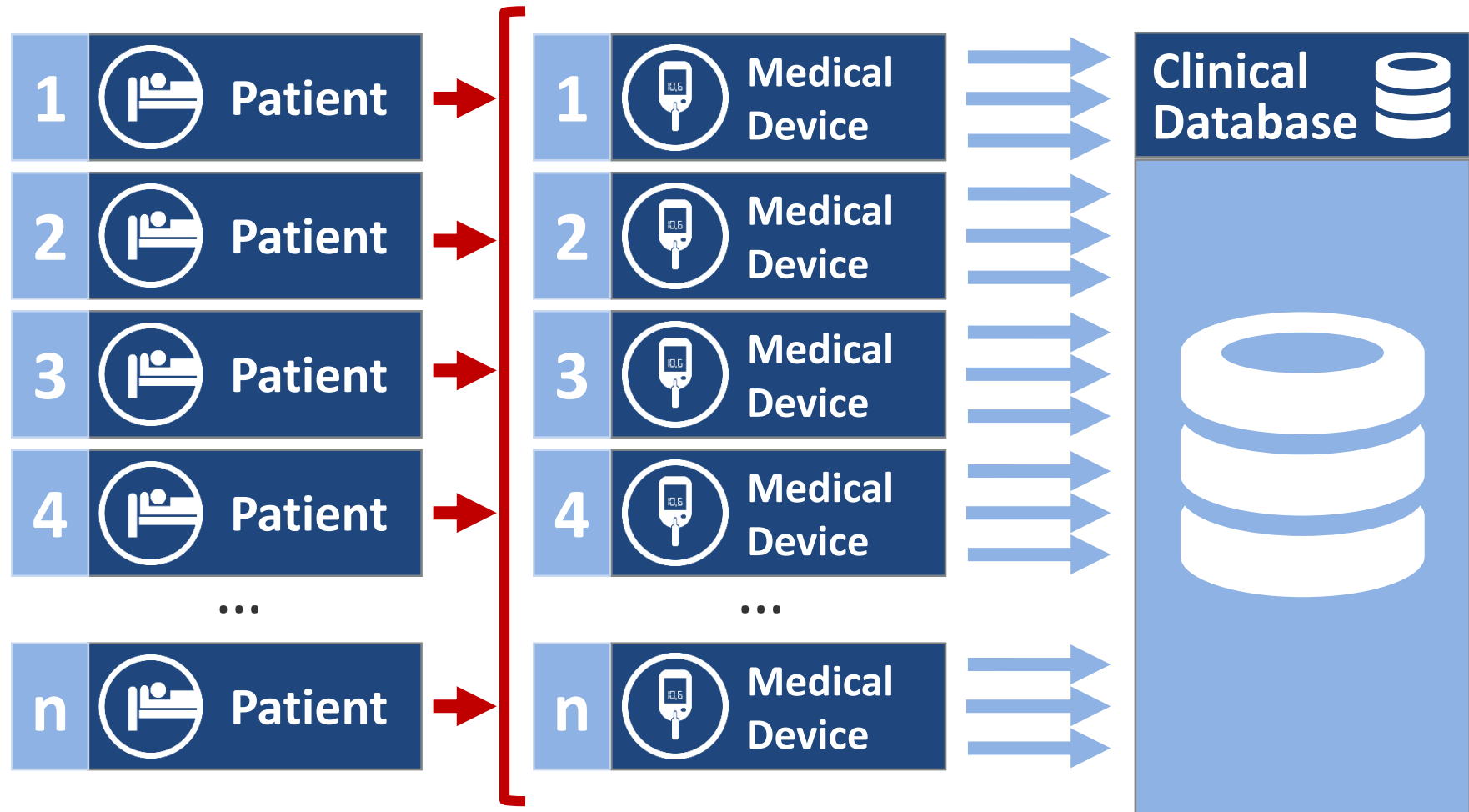
Challenges

Data variety & complexity



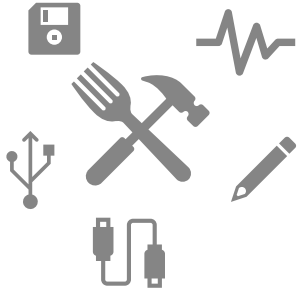
Challenges

Data variety & complexity





Compartmentalization & heterogenous landscape



- Complex Information
- Numerous different devices, standards, formats & protocols
- Security & privacy concerns
- Data harmonization



Corruption & Availability

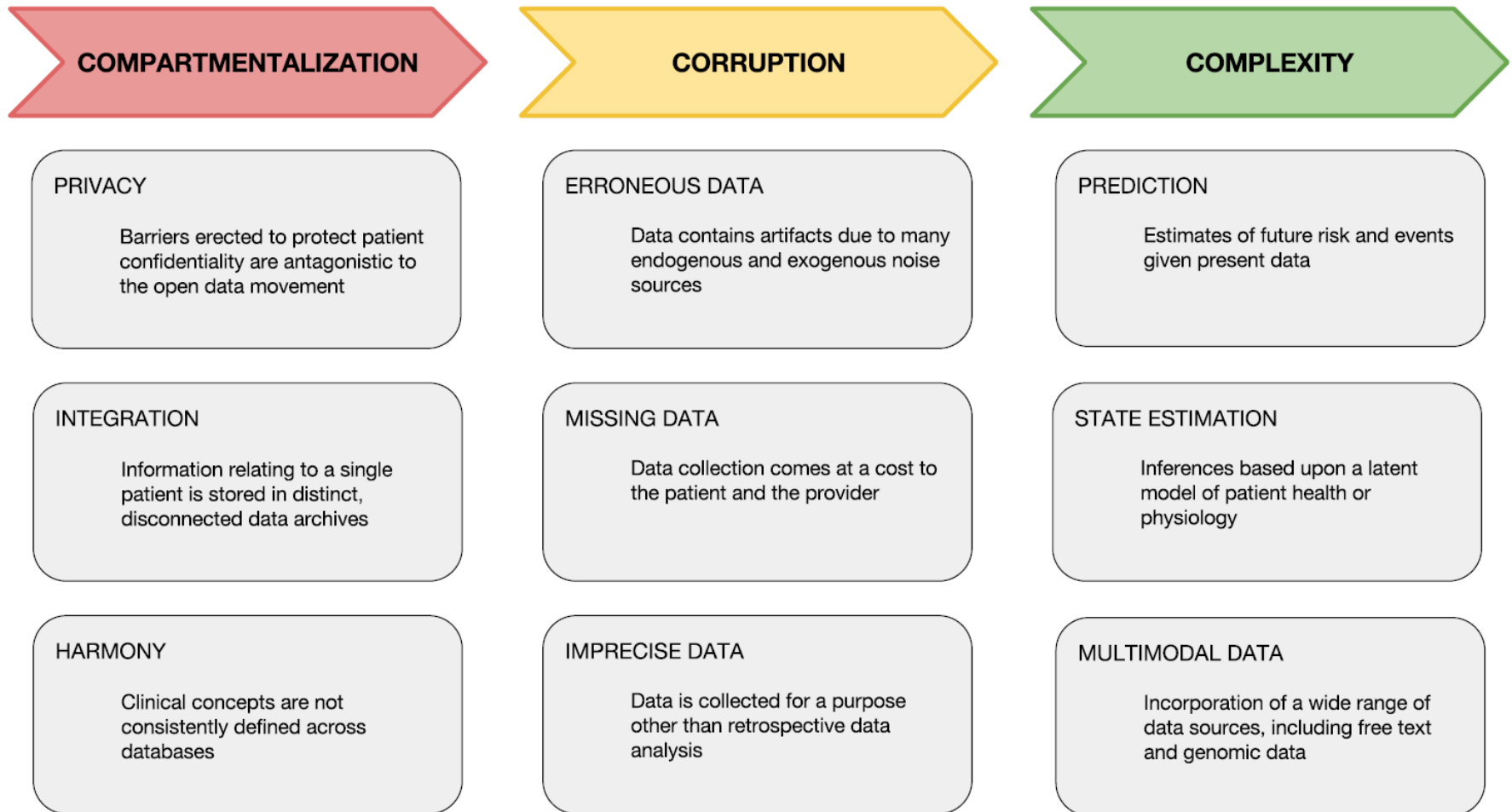
- Limited reliability
- Limited availability



Complexity & Storage

- Large amounts of heterogenous data

Major challenges for data integration & further processing



from: Johnson et al. *Machine Learning and Decision Support in Critical Care Proceedings of the IEEE Vol. 104 Issue 2 Feb 2016 p. 444 -- 466*

Challenges

Summary



Complex, heterogeneous environment

- Difficult to gather the required data
- Still a long way to complete HIS



Complex, incomplete & corrupted data

- Automated processing requires validations
- Manual therapeutic interactions / data artifacts



Different data needs

- Intended usage defines the most important aspects



Data integration is an important challenge for the next decade(s)

- Needed for digital health and personalized medicine
- Different interests of involved parties

WE OFFER 3 KINDS OF SERVICES

= data

GOOD-CHEAP-FAST

BUT YOU CAN PICK ONLY TWO

GOOD & CHEAP WON'T BE **FAST**

FAST & GOOD WON'T BE **CHEAP**

CHEAP & FAST WON'T BE **GOOD**

Modified from: <https://blog.cloudflare.com/the-trouble-with-tor/>



National & Global Efforts

Standardization and Harmonization Approaches



Clinical standardization approaches

Examples:

- **Health Level Seven (HL7)** <http://www.hl7.org>
- **ISO/IEEE 11073**
Health informatics - Medical / health device
communication standards
- **DICOM**
Digital Imaging and Communications in Medicine
- **HL7 FHIR, SNOMED, OMOP, LOINC**



Joint efforts



Example: HL7

Different versions:

HL7 v2 Delimiter-based

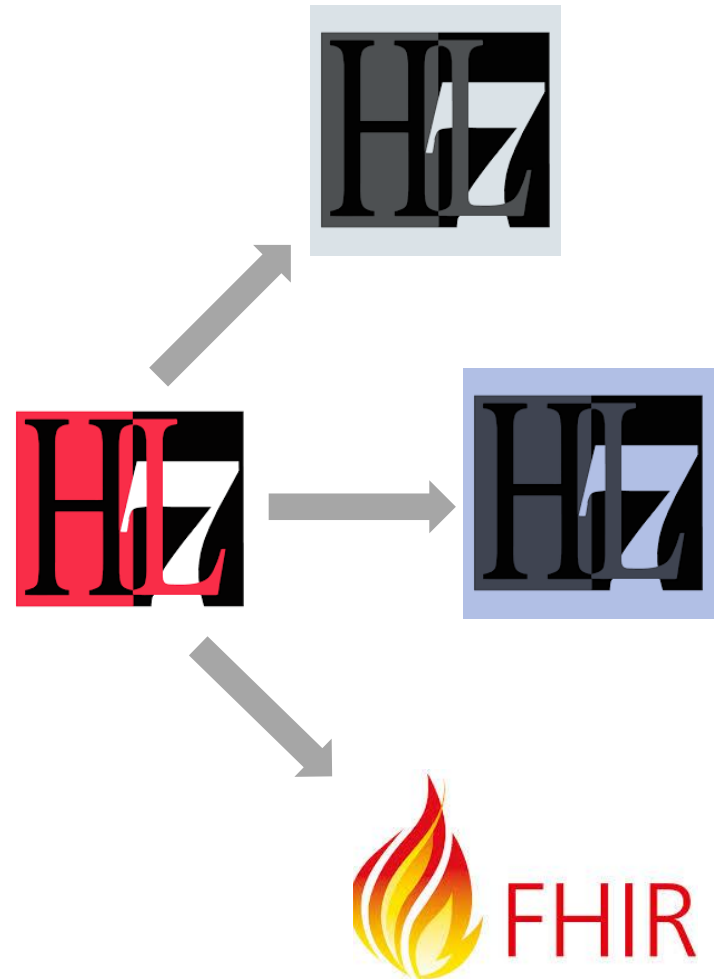
```
value1|value2|value3
```

HL7 v3 XML-based

```
<block>  
  <key>value</key>  
  <key  
code=123>value2</key>  
</block>
```

HL7 FHIR JSON (or XML)-based

```
{'block':  
  {'key': 'value',  
   'code': 123}}
```





Example: HL7 v2

- Originally created in 1989
- Further improved in the recent years (v2.x)
- Message-based standard
- Text & delimiter based („|“ pipe character)

```
MSH|^~\&|Sen|SFac|Rec|RFac|20171010090105||ADT|0123|P|2.5
```



Joint efforts



Example: HL7 v2

Different Message types

ADT: Admission, Discharge, Transfer

ORM: Order Message

ORR: Order Response

ORU: Observation Result Unsolicited

MDM: Medical Document Management

DFT: Detailed Financial Transaction

BAR: Billing Account Record

...



Joint efforts



Example: HL7 v2

Different Segment types

EVN: Event Type
MSH: Message Header
OBR: Observation Request
OBX: Observation Result
ORC: Common Order
PID: Patient Identification
PV1: Patient Visit
SFT: Software Segment
...



Joint efforts



Example: HL7 v2

Admission message example (abbreviated):

Header	Sender / Receiver	Data	Message-Type	-ID	Ver
MSH	^~\& Sen SFac Rec RFac	20171010090105	ADT	0123 P	2.5

Date

EVN	201710100901	201710100901
-----	--------------	--------------

Patient ID List	Name	DOB	Address
PID	1234567	DOE^JOHN	19870605 M

Patient Class, Location, Attending Doctor	Admission Date
PV1	I W^123^1^BED^^3

OBX	2 NM ^Body Weight	79 kg^Kilogram^ISO+	F
-----	-------------------	---------------------	---

OBX	1 NM ^Body Height	1.80 m^Meter^ISO+	F
-----	-------------------	-------------------	---



Joint efforts



Example: HL7 FHIR[®] [©]

Fast Healthcare Interoperability Resources

- Based on Resources
- XML, JSON and further representations

Example – JSON representation of patient resource (Excerpt, incomplete):

```
{
  "resourceType": "Patient",
  "identifier":
    [{
      "use": "usual",          "system": "urn:oid:1.2.36.146.595.217.0.1",
      "value": "12345",       "period": { "start": "2001-05-06" },
      "assigner": { "display": "Acme Healthcare" }
    }],
  "name":
    [{ "use": "official", "family": "Chalmers", "given": [ "Peter", "James" ] },
      { "use": "usual", "given": [ "Jim" ] }],
  "gender": "male",
  "birthDate": "1974-12-25",
  "deceasedBoolean": false,
  ...
}
```

Name Identifier



Joint efforts



Example: LOINC

Logical Observation Identifiers Names and Codes

<https://loinc.org/>

Developed by the Regenstreif Institute (<https://www.regenstrief.org>)



a common language

(set of identifiers, names, and codes) for identifying health measurements, observations & documents.



Unique, permanent numeric codes



Full Specified Name (FSN)

<Analyte/Component>:<Property>:<Time aspect>:<System (sample)>:<Scale>:<Method>



Long Common Name (LCN)



Short Name

+ Stored for different languages!

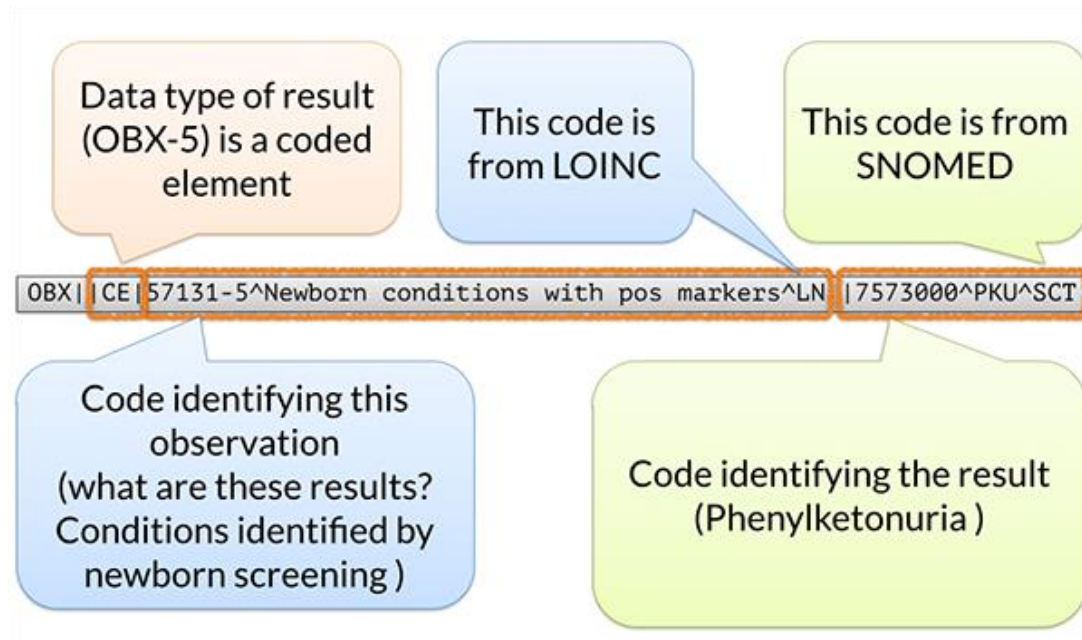


Joint efforts



Example: LOINC

In HL7 message:



[<https://loinc.org/get-started/what-loinc-is/>]

Another Example with the different encoded names:

Code: 3094-0

FSN: Urea nitrogen:MCnc:Pt:Ser/Plas:Qn:

Harnstoff-Stickstoff:MKnz:Pkt:Ser/Plas:Qn:

LCN: Urea nitrogen [Mass/volume] in Serum or Plasma

Short: BUN SerPl-mCnc

Display: Urea nitrogen [Mass/Vol]



Joint efforts



Example: UCUM

Unified Code for Units of Measure

<http://unitsofmeasure.org>

Developed by the Regenstreif Institute (<https://www.regenstrief.org>)

Goal: Harmonize annotations

System for measurement units – used e.g. in LOINC & FHIR



7 Base Units (meter m, second s, gram g, radian rad, Kelvin K, Coloumb C, candela cd)



Approx. 30 Standard Prefixes/multipliers (e.g. kilo k, milli m , 10^3 ...)



Units (unit atoms) derived from base units & multipliers

- E.g. minute:min=60s , liter: L = dm^3



Example: UCUM

Example: **mg/dL** milli gramm *per* deci liter (= $\text{dm}10^3$)

Examples for further annotations:

- $10^9/\text{uL}$ MillionsPerMicroLiter
- $\text{mm}[\text{Hg}]$ MilliMetersOfMercury (Constants in [])
- $10^3.\{\text{RBC}\}$ ThousandRedBloodCells (Annotations in { } not standardized)
- $\%\{\text{Oxygen}\}$ Percent Oxygen
- $[\text{IU}]/10^9\{\text{RBCs}\}$ IU per 10^9 RBCs
- $\text{mmol}/(8.\text{h}.\text{kg})$ millimole / 8 * hour * kilogram

➔ Defined structure for further processing
Important step to integrate & compare different datasets

Current Research & Outlook

The future of data integration



Data Collection, Integration & Automation in the ICU



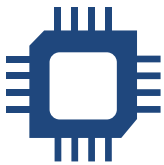
Insight to current research

Establishment of data collection



- Accessing device interfaces
- Novel data collection (ACT, Diuresis, ...)

Development of integrated frameworks



- Bridging the information gap
- Interconnection of various medical devices

Assisted / automated therapies



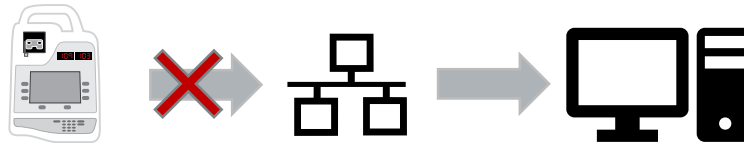
- Goal-directed therapies
- Closed-loop management



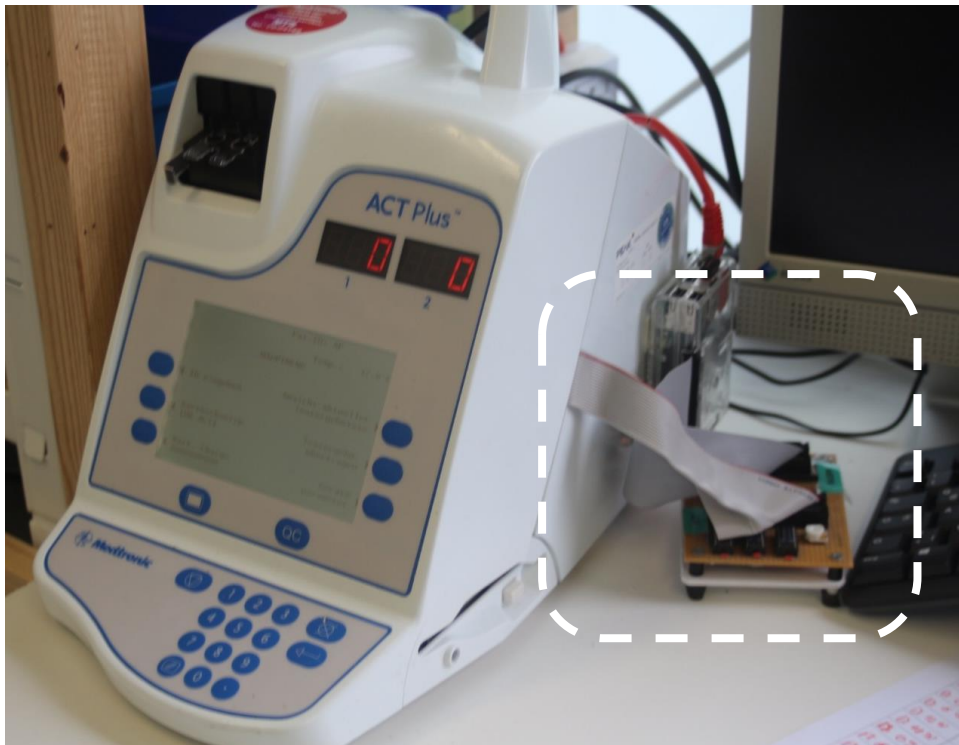
Problem: Availability of data

Example 1: Point-of-care ACT measurement

Recap – Problem:



Solution:



https://en.wikipedia.org/wiki/Raspberry_Pi#/media/File:Raspberry_Pi-3-Flat-Top.jpg

Signal extraction with converter board & Raspberry Pi micro-computer

Real-time transmission of the results via Ethernet

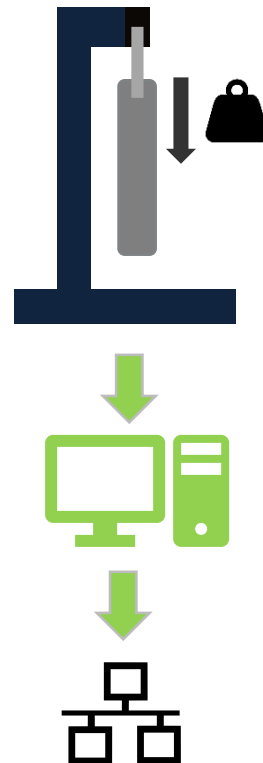




Problem: Availability of data

Example 2: Diuresis Measurement

Recap – Problem:  Manual reading & notes



Solution:

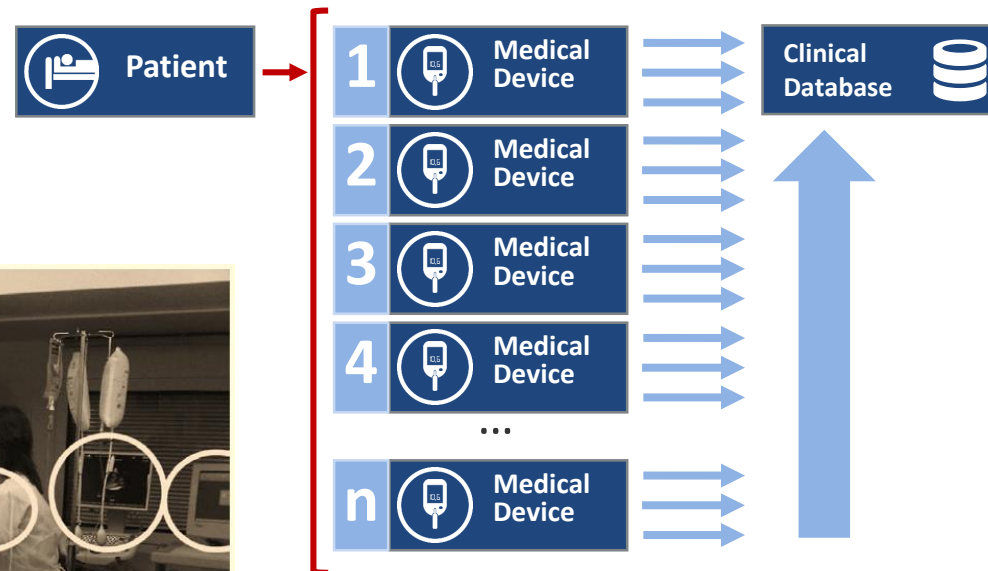
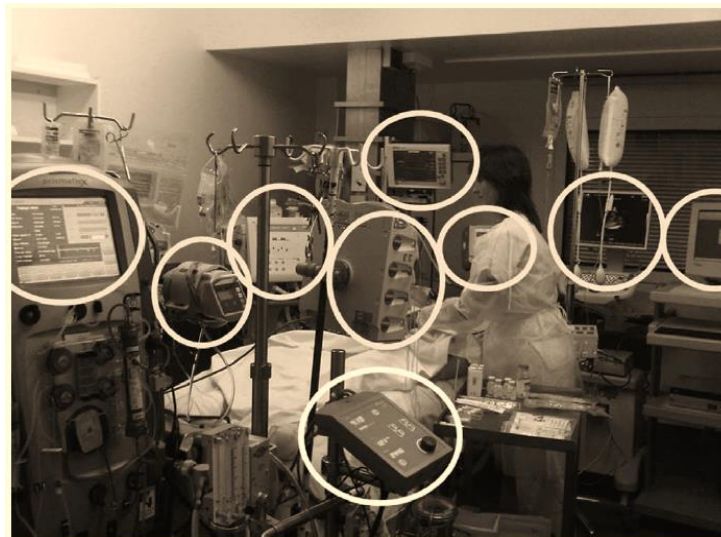
Urine collection bag
suspended on a load cell
for weight measurement

Automatic processing
& storage of the measurements

serial communication of the scale
with a computer with Ethernet
connection



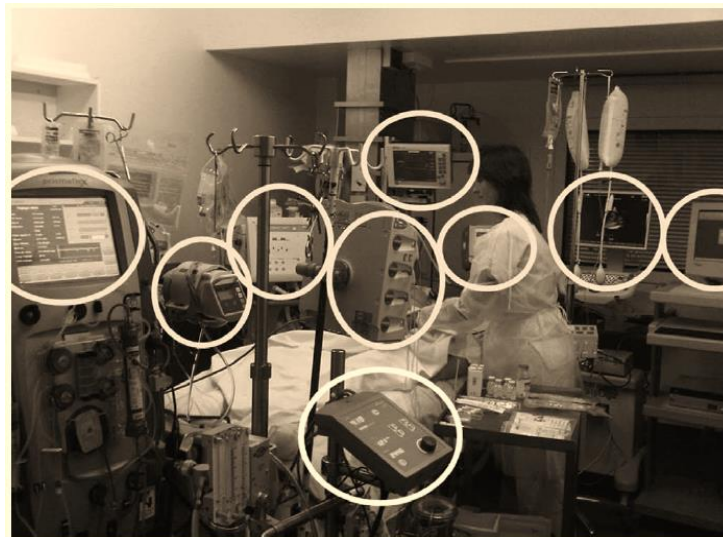
Distributed Information



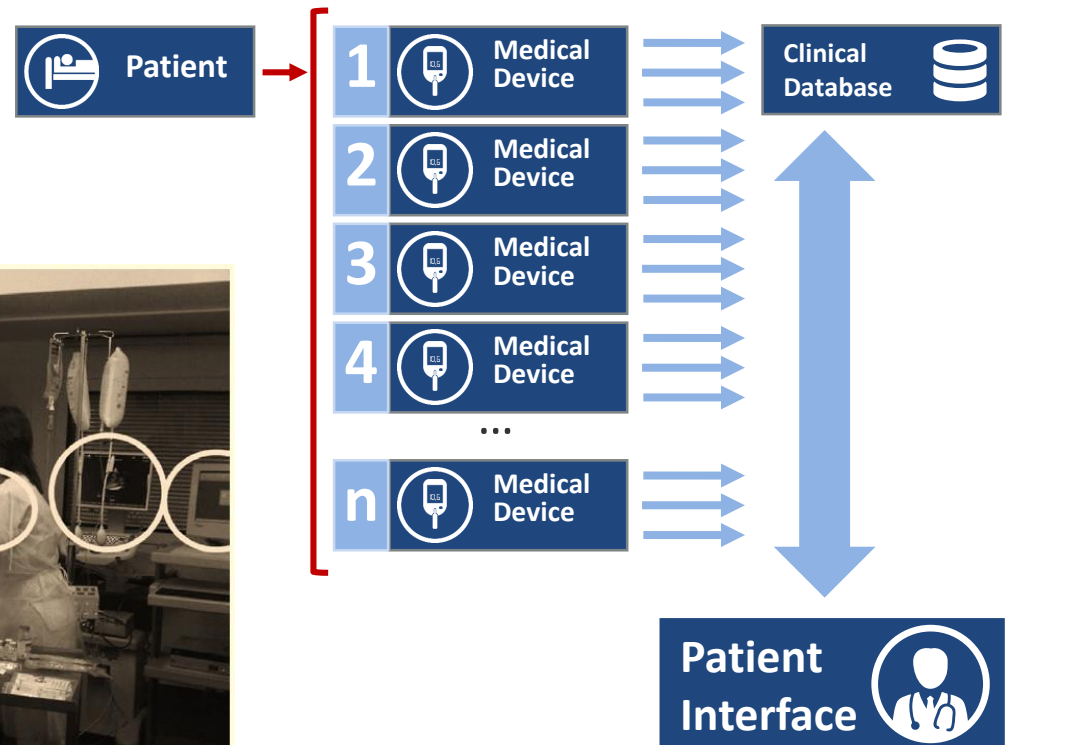
Modified from:
Crit Care Med. 2016;44(2):386-9 The Future of Critical Care Medicine:
Integration and Personalization. Vincent JL.



Distributed Information



Modified from:
Crit Care Med. 2016;44(2):386-9 The Future of Critical Care Medicine:
Integration and Personalization. Vincent JL.



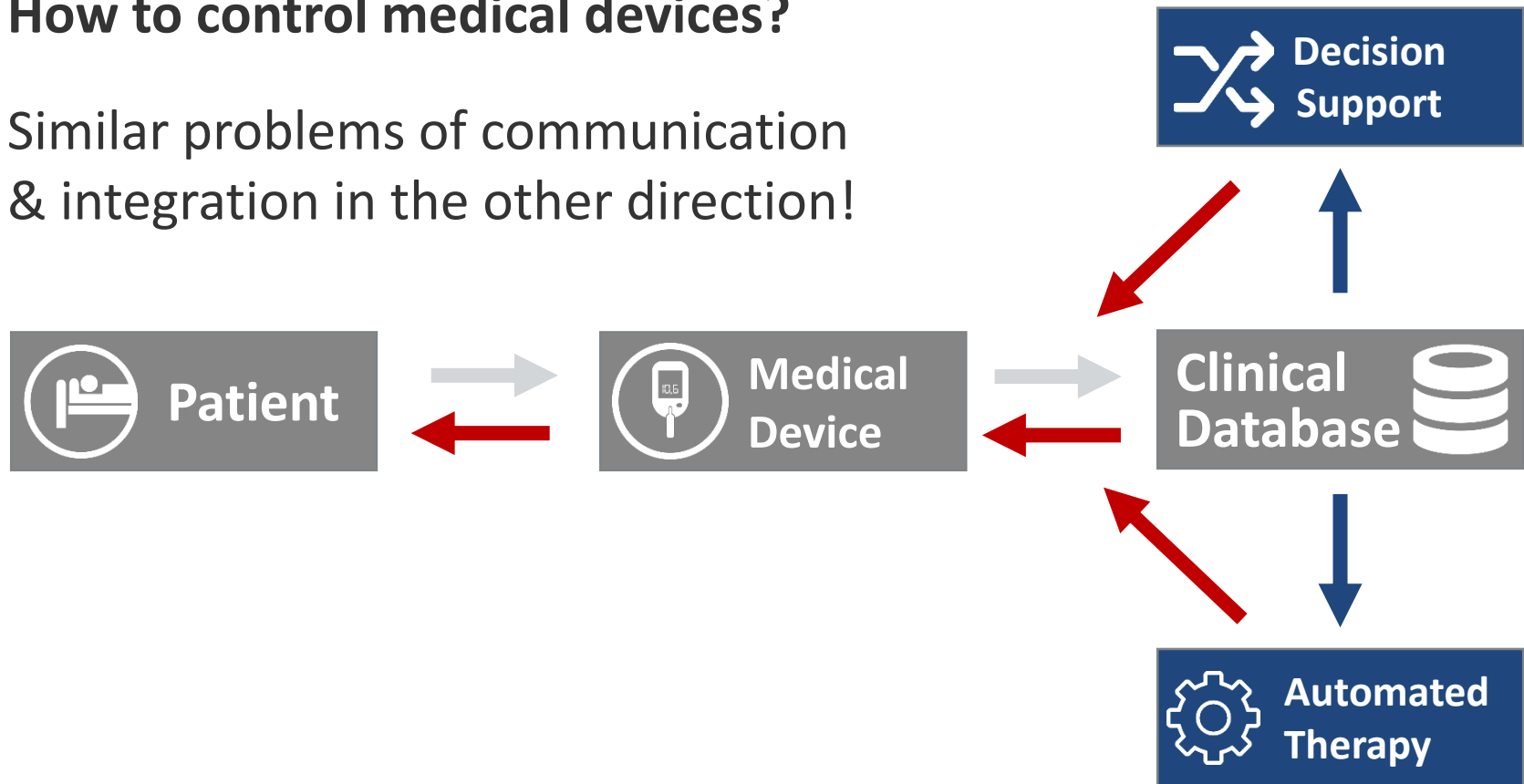
**Data integration into a
central patient interface**



Assisted / Automated Therapy

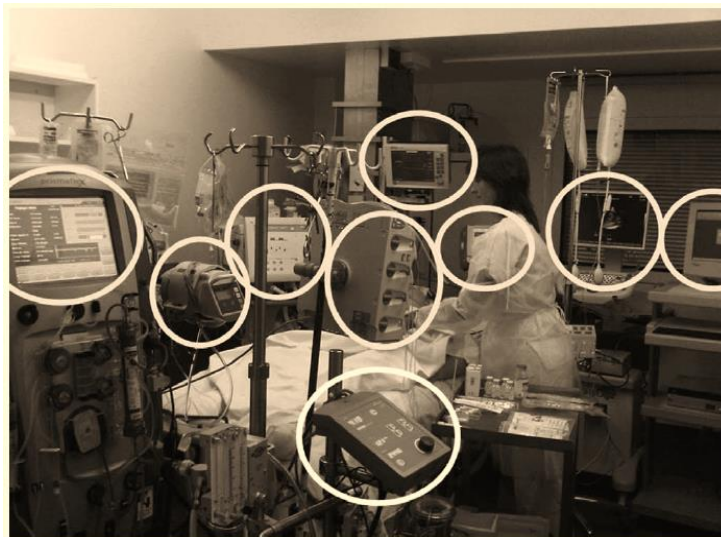
How to control medical devices?

Similar problems of communication
& integration in the other direction!

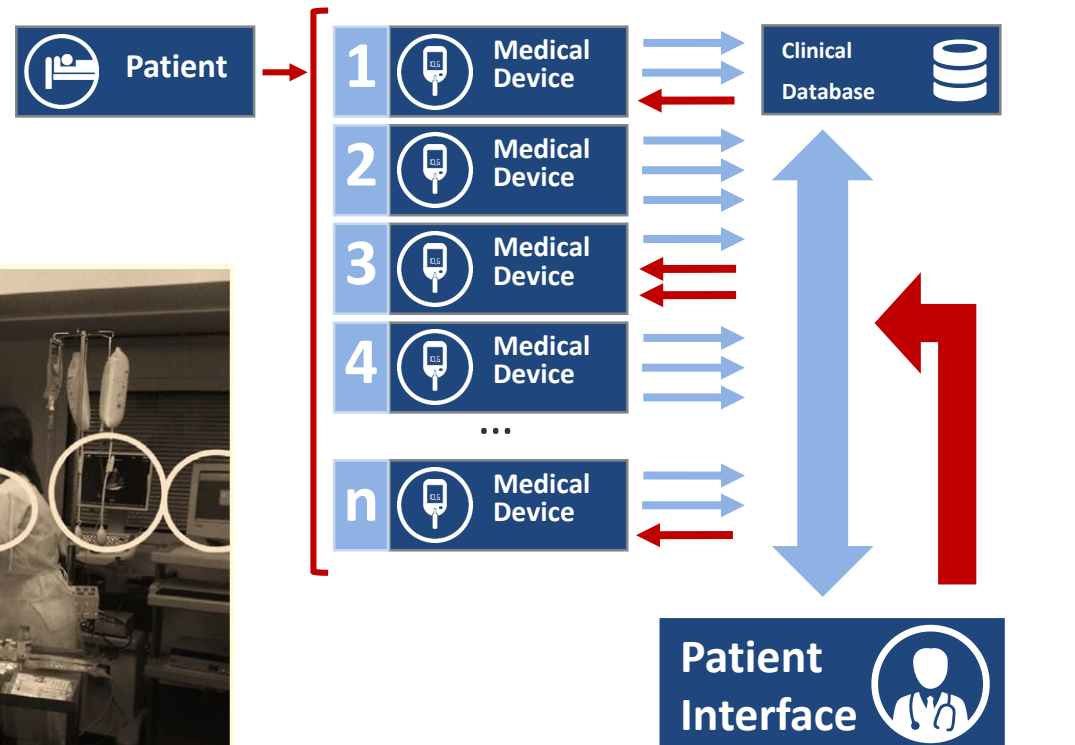




Assisted / Automated Therapy



Modified from:
Crit Care Med. 2016;44(2):386-9 The Future of Critical Care Medicine:
Integration and Personalization. Vincent JL.



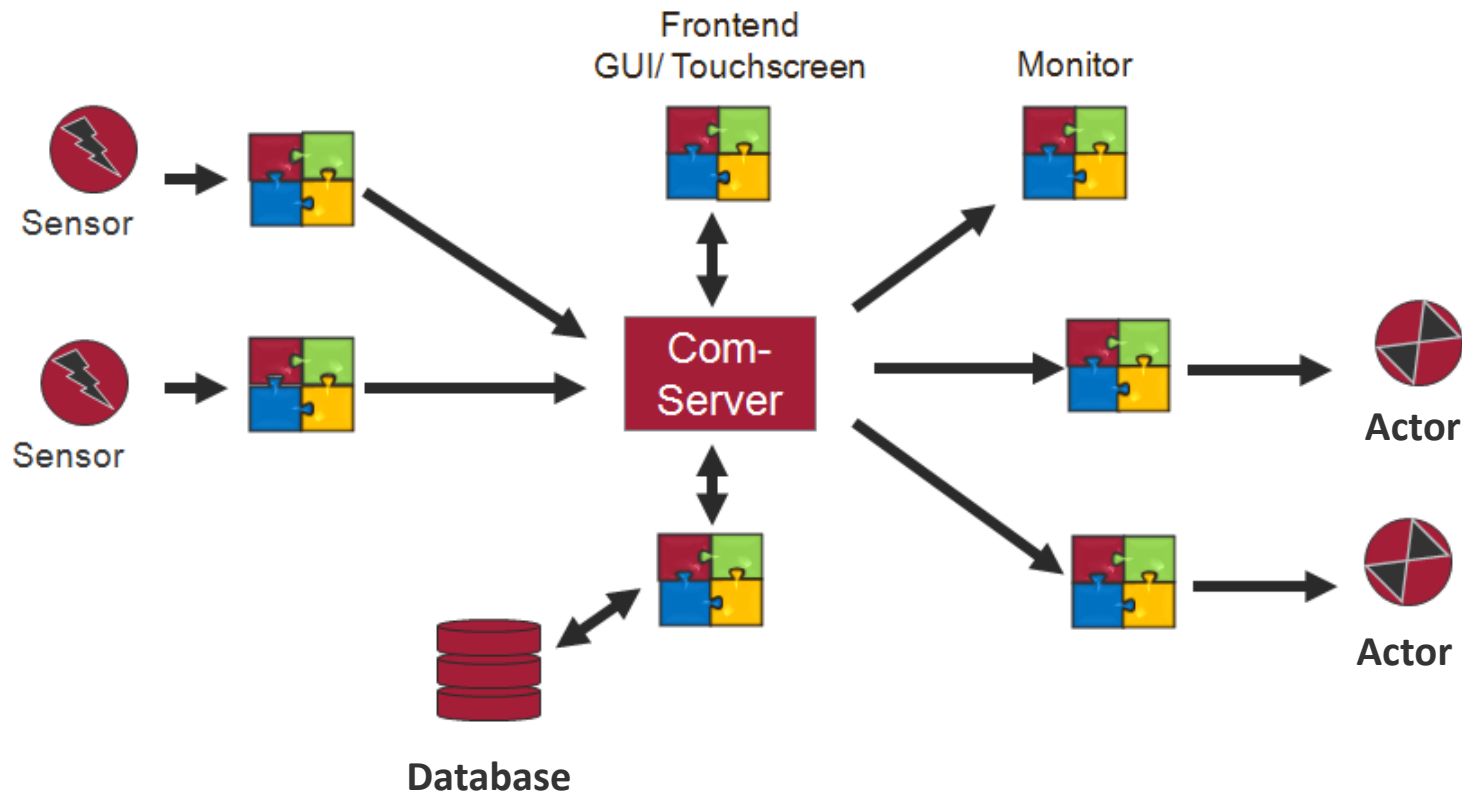
Data integration into a
central patient interface

Monitoring & control



Integrated ICU Framework

Modular & reusable software components

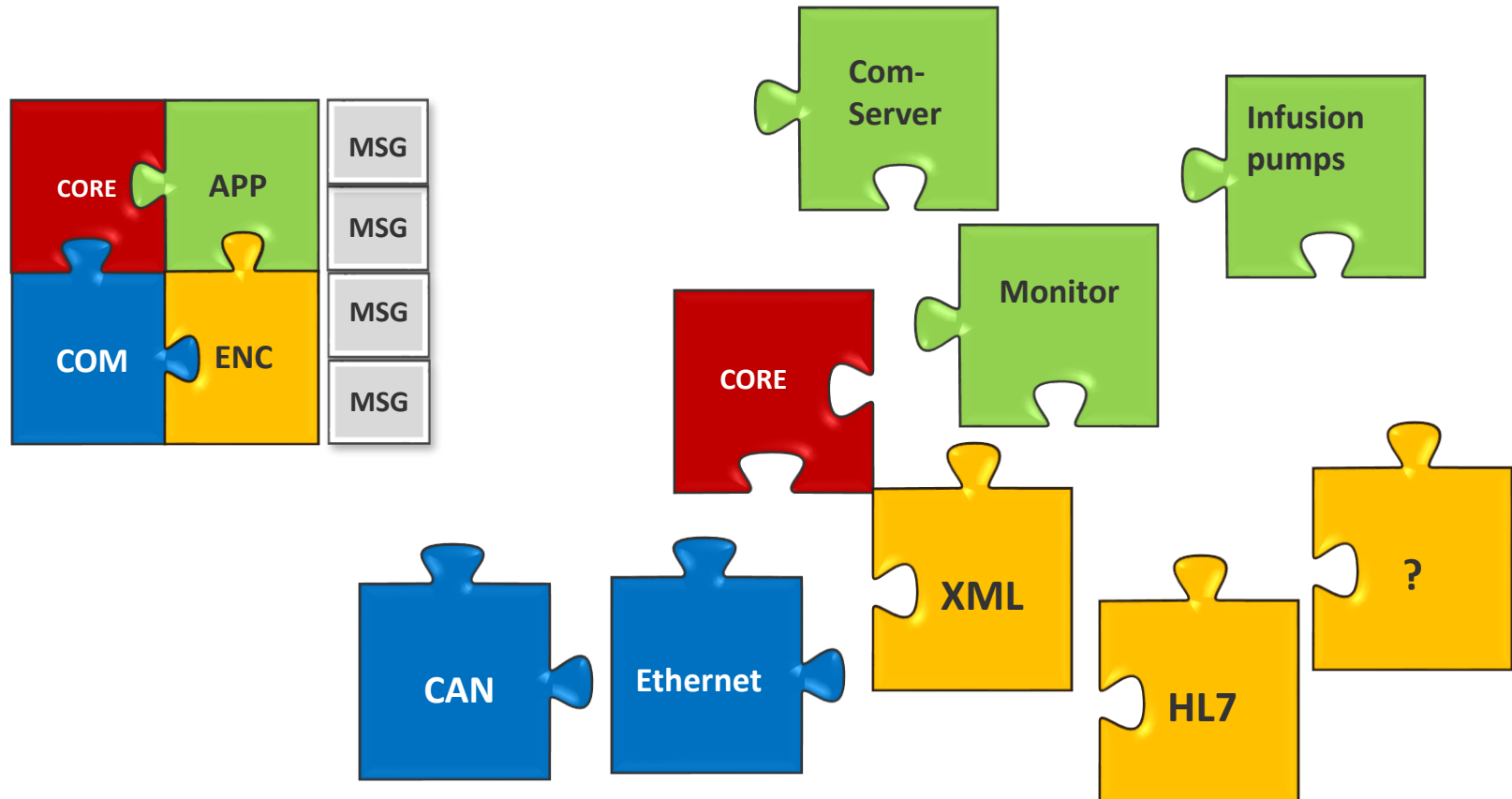


Peter et al. (2014) *TICoMS -- A Modular and Message-Based Framework for Monitoring and Control of Medical Devices*. 2014 IEEE 27th International Symposium on Computer-Based Medical Systems (CBMS)



Integrated ICU Framework

Inclusion of various applications, interfaces and device → Universal system





One patient - one screen



Gather all relevant patient information

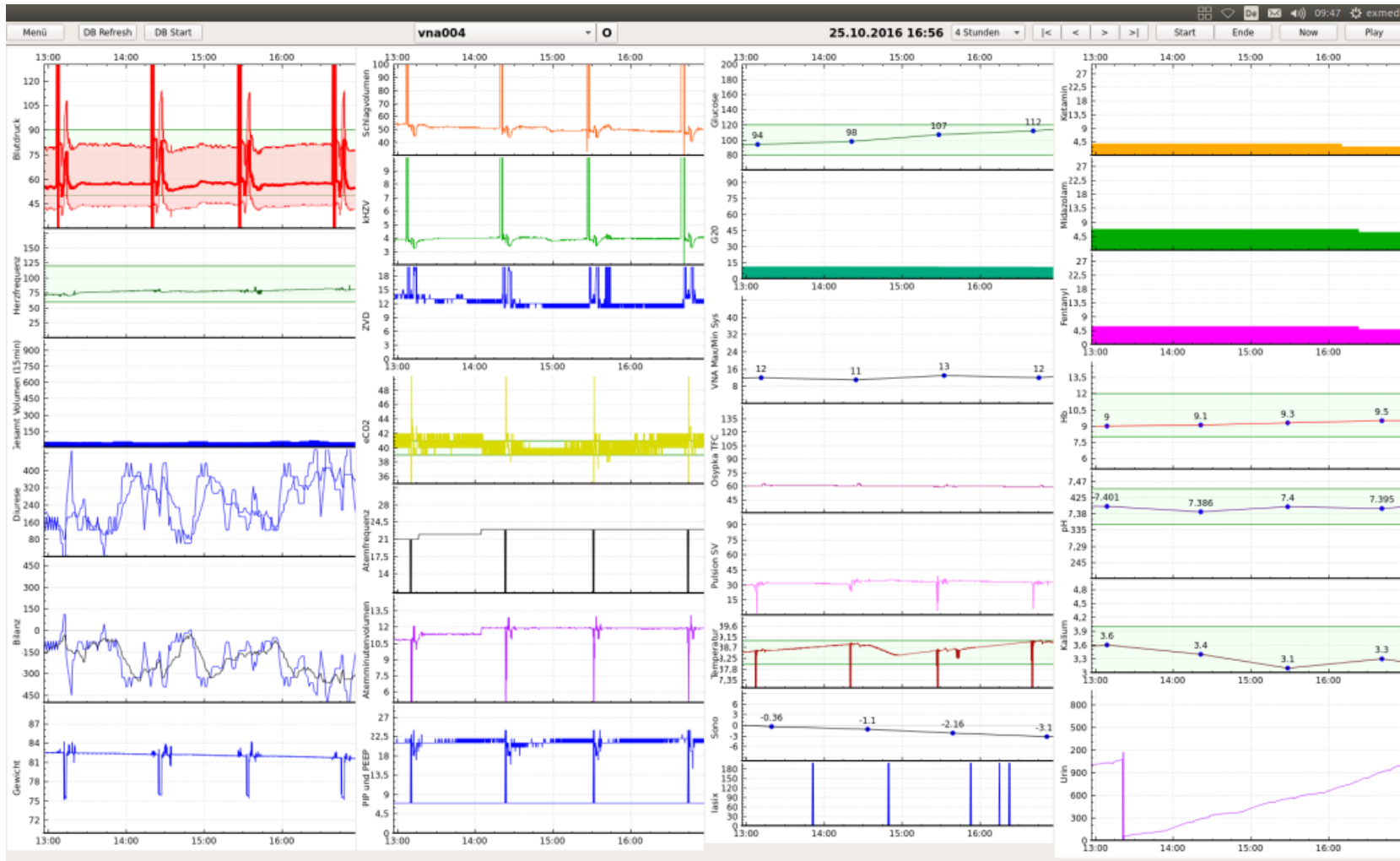
- Real-time data from medical devices
- Laboratory results
- Historical data
- ...

Control medical devices & therapies

- Set infusion pumps
- Ventilator settings
- Checklists
- Stepwise therapeutic protocols
- Manouvers
- Caregiver's comments
- ...



Real-time & historic patient data





Portable on hand-held devices



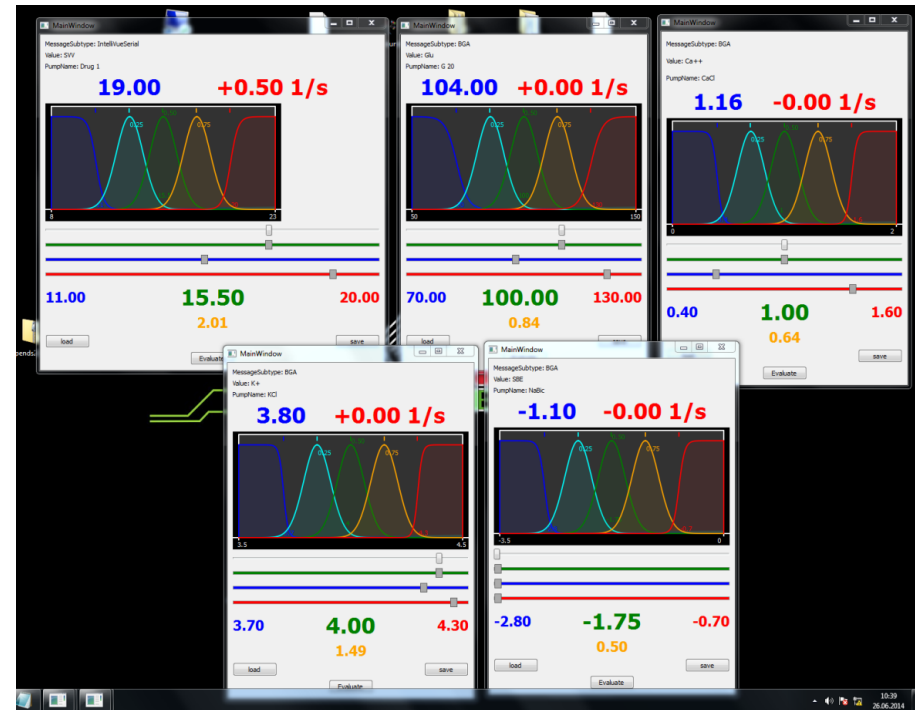


Assisted / automated therapy



Goal-directed therapy

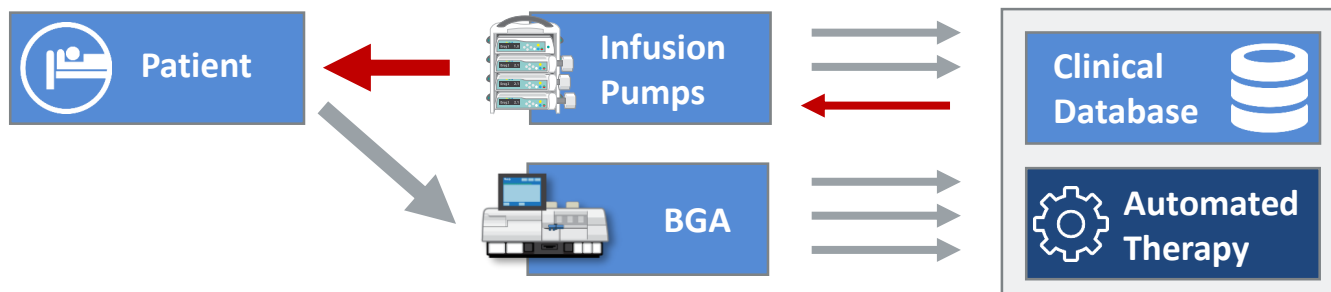
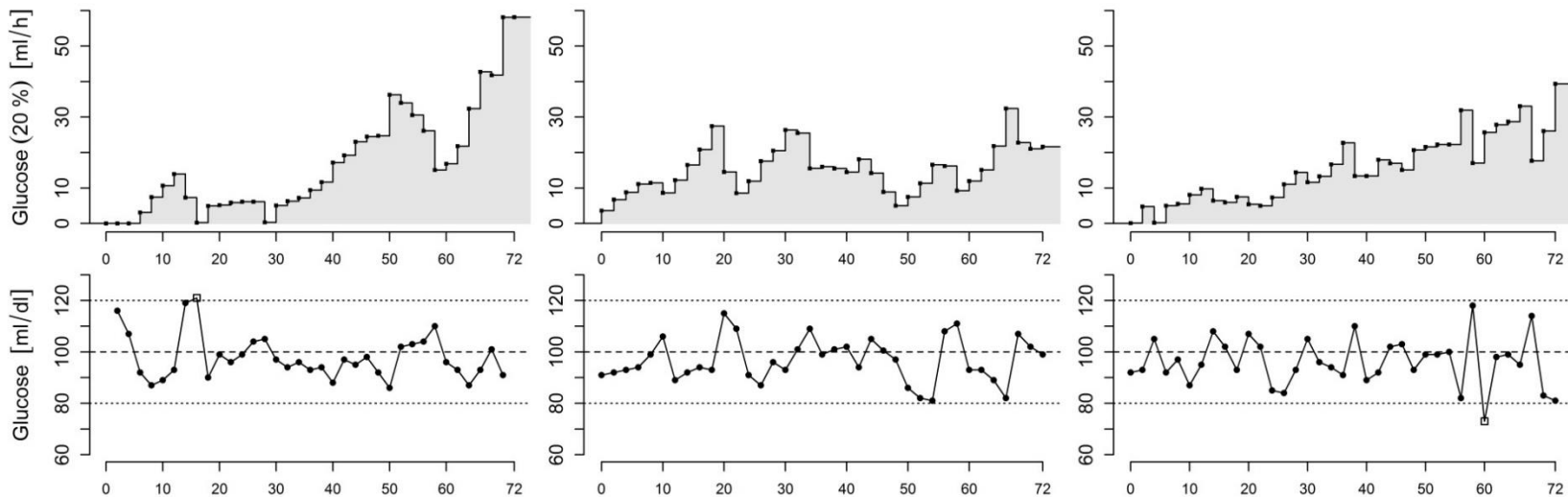
Closed-loop control



Development Interface for fuzzy logic-based goal-directed therapies

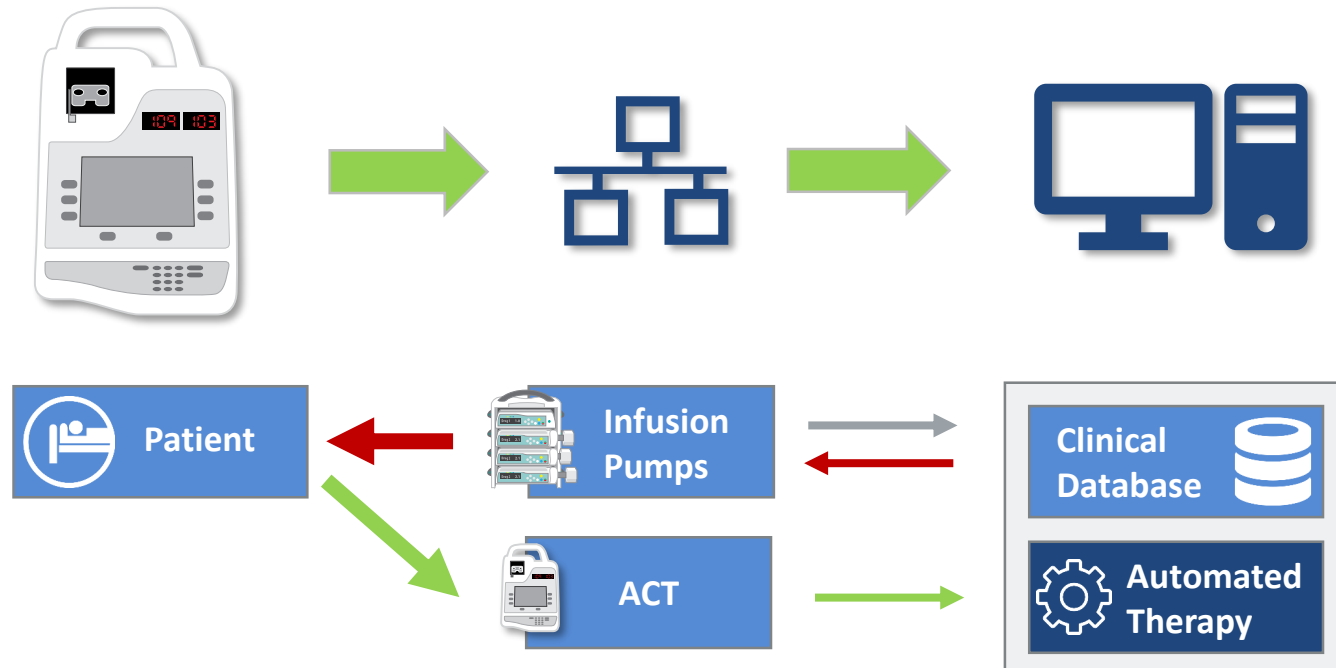


Automated glucose management





Automated heparinization



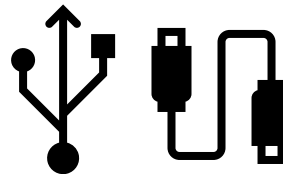
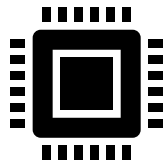
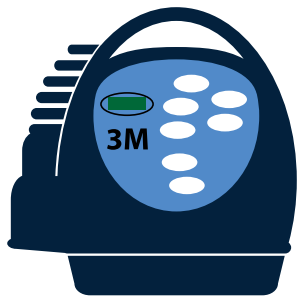
- Automated processing of the ACT measurements
- Weight-adapted dose calculation with look-up table
- Automated adaption of infusion pump & bolus

Peter et al. (2017) *Automated therapeutic anticoagulation: A closed-loop approach using a modified measurement device* 2017 13th IASTED International Conference on Biomedical Engineering (BioMed)



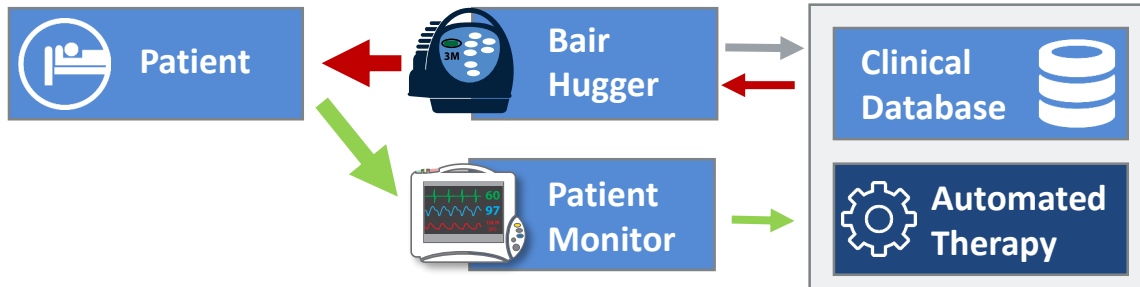
Automated temperature management

- Measurement of patient's body temperature by Patient Monitor
- Adaption of the 3M Bair Hugger settings



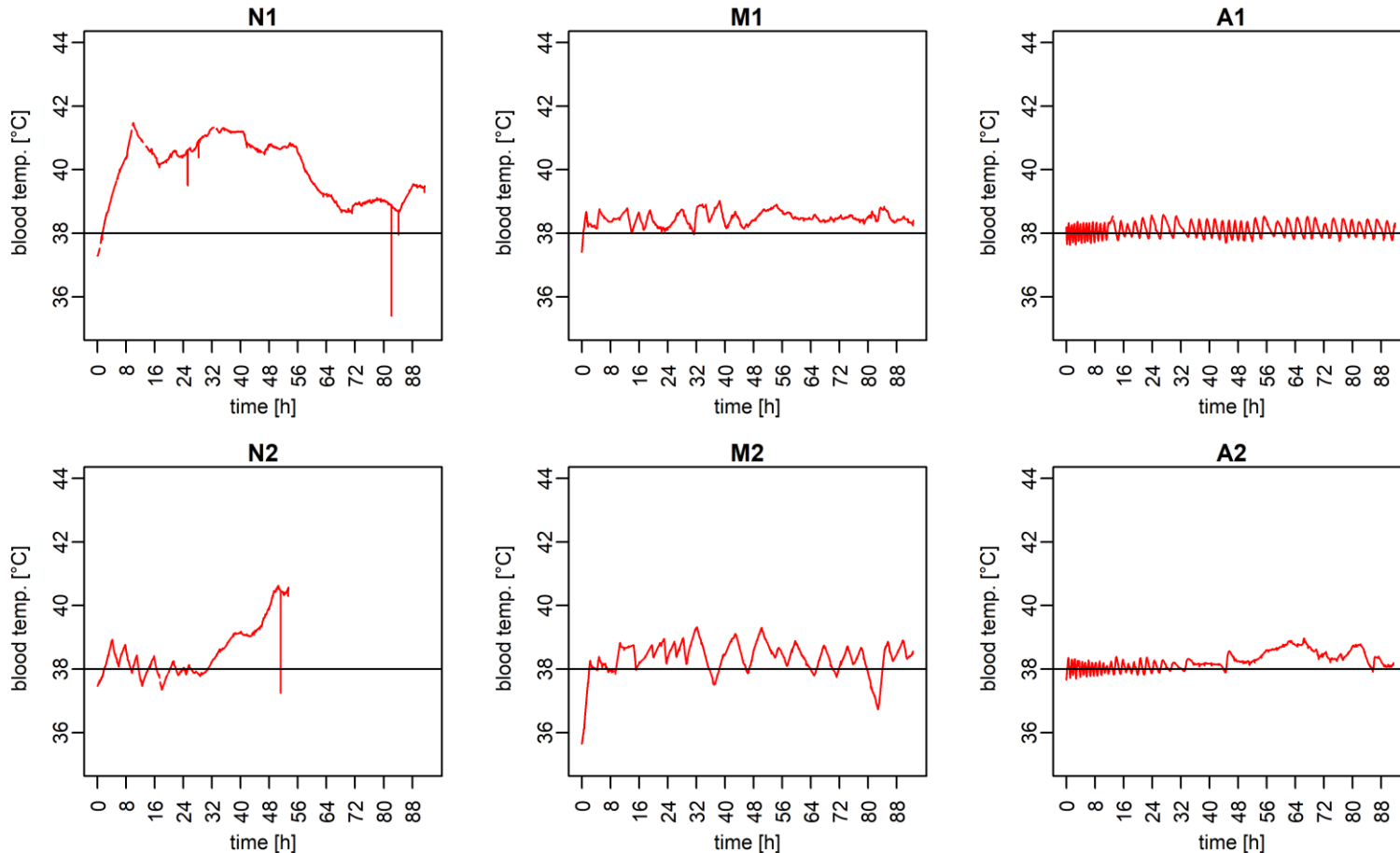
extra circuit

USB
read & control

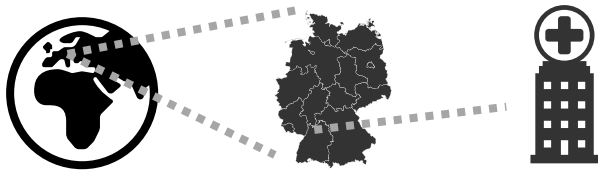




Automated temperature management



Peter et al. (2017) Automated closed-loop management of body temperature using forced-air blankets: preliminary feasibility study in a porcine model. *BMC Anesthesiol.* 2018 Jul 3;18(1):80.



National & hospital-wide projects

Medical Informatics Initiative

<http://www.medizininformatik-initiative.de>



**Sponsored by the German Federal
Ministry of Education and Research**

Aim



- Development of common standards
- Nation-wide sharing of care and research data



**4 consortia for developing
data integration solutions**

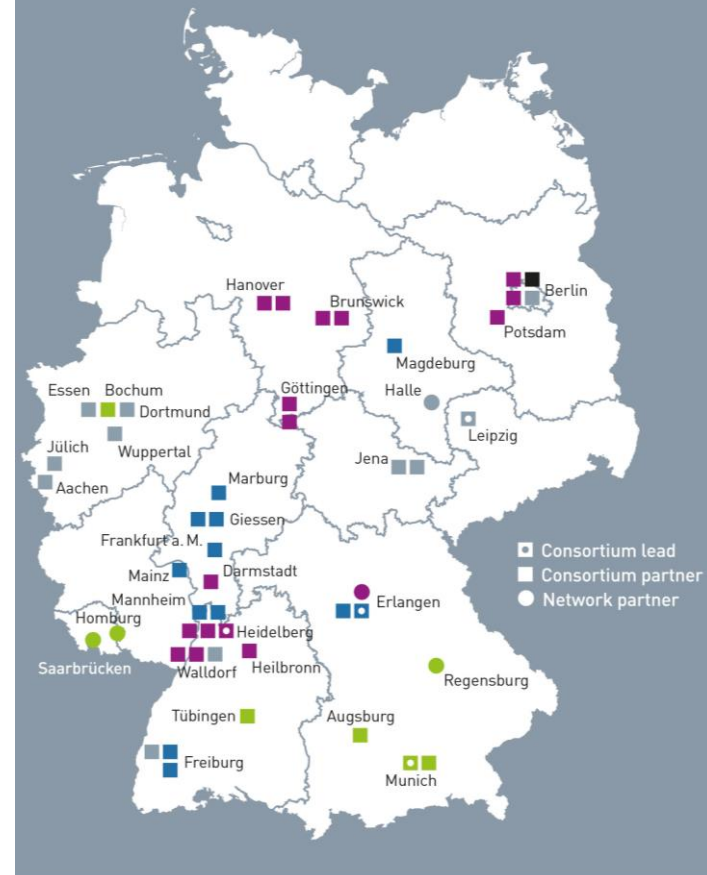
One of them:

DIFUTURE

Data Integration for Future Medicine

<https://difuture.de>

Consortia and participants
during the development and networking phase



DIFUTURE
HiGmed
MIRACUM
SMITH
Coordination office



[medizininformatik-initiative.de 2018]



Use-case driven for patient benefit

Multiple Sclerosis

Improve disease modifying treatment

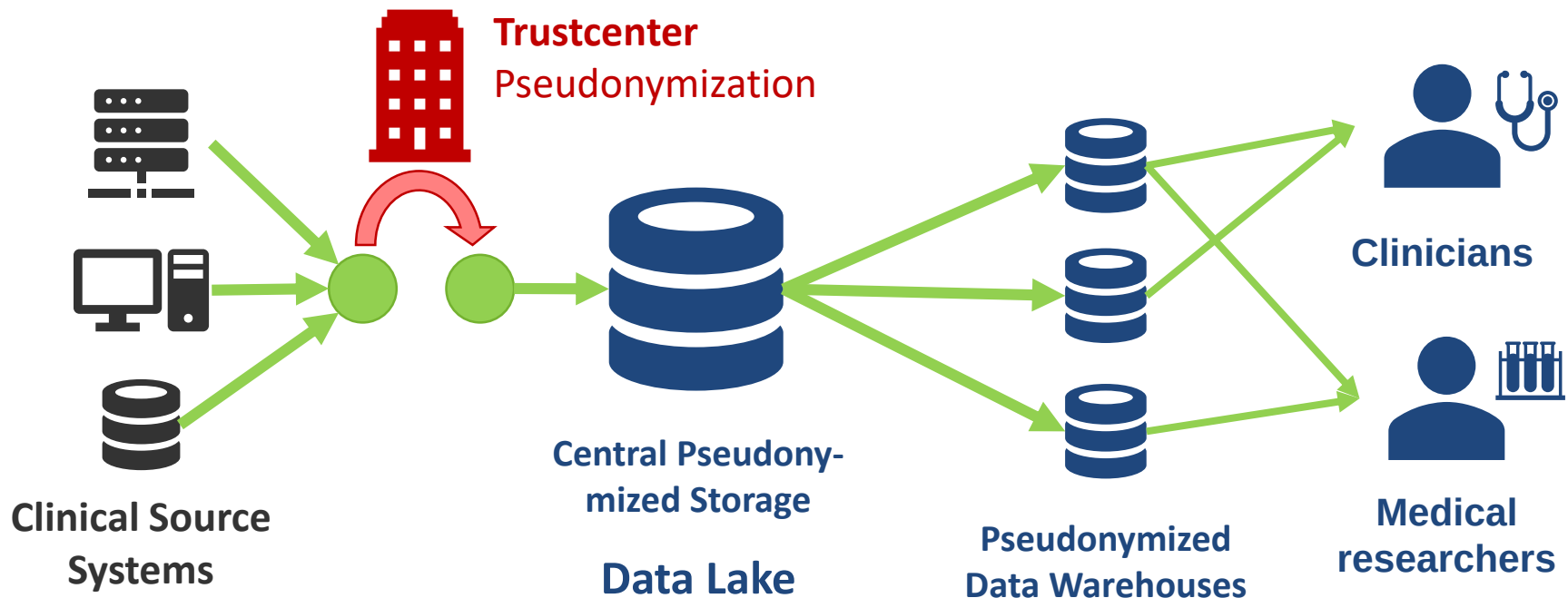
Parkinson's Disease

Early diagnosis with multi-modal data

Molecular Tumor Board

Improve therapy decisionmaking

In a nutshell:



Bring Algorithms to the Data — Personal Health Trains



DIFUTURE

Data Integration for Future Medicine

<https://difuture.de>

SMITH

Smart Medical Information
Technology for Healthcare

<http://www.smith.care>

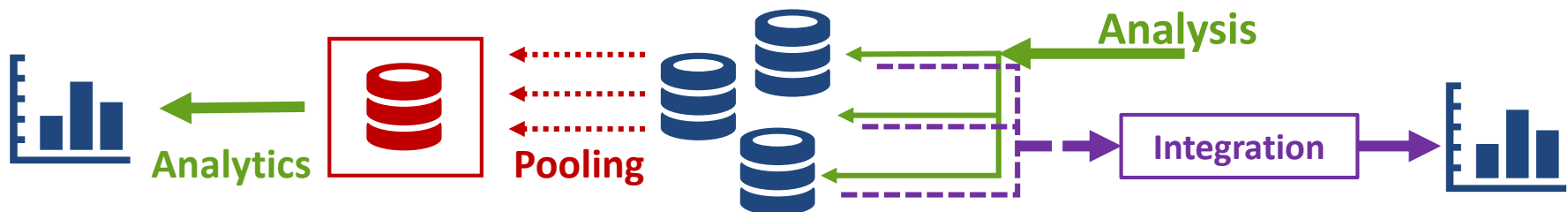
GOFAIR

<https://www.go-fair.org>

Data Pooling

vs.

Distributed Computing

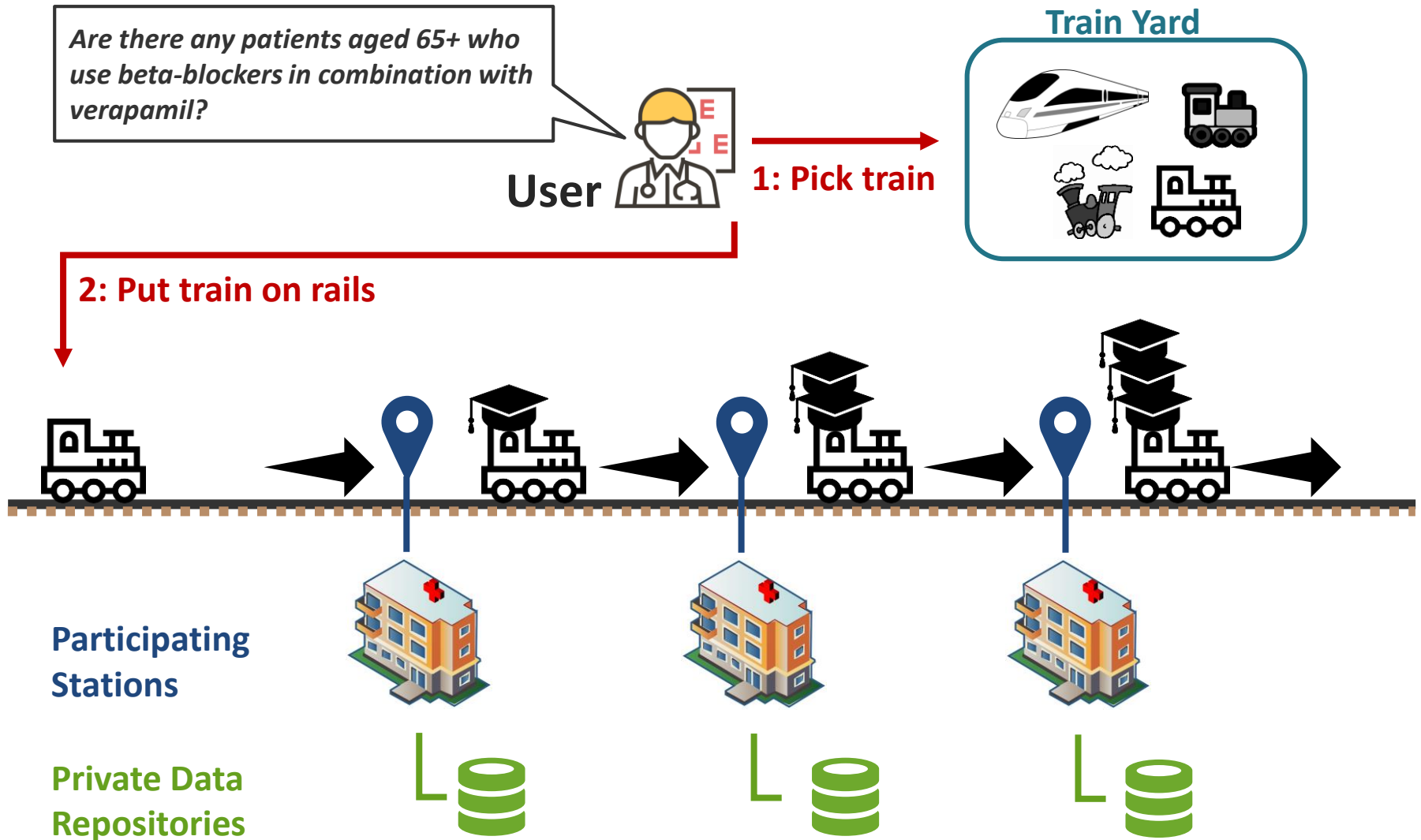


- Requires transfer of all data to a centralized data pool
- Very little infrastructure required

- Analysis executed locally – data remains local
- Only aggregated results returned and integrated
- Requires complex infrastructure & modified analytics

Personal Health Trains

Use Case Example



Thanks.

Contact:

Dr. rer. nat.

Jörg Peter

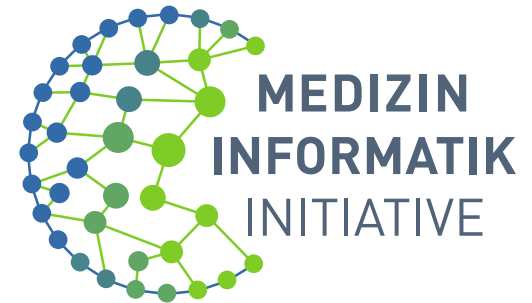
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Department for Information Technology
& Applied Medical Informatics

Institute for Translational Bioinformatics
Sand 13, 72076 Tübingen

Phone: +49 7071 29-70438

joerg.peter@uni-tuebingen.de



DIFUTURE

Data Integration for Future Medicine

GEFÖRDERT VOM



Bundesministerium
für Bildung
und Forschung

- The Biomedical Engineering Handbook, 4th Edition
Bronzino, J.D. and Peterson, D. R.
Taylor & Francis, 2015
- The Future of Critical Care Medicine: Integration and Personalization. Vincent JL.
Crit Care Med. 2016;44(2):386-9
- *Machine Learning and Decision Support in Critical Care*
Johnson et al.
Proceedings of the IEEE Vol. 104 Issue 2 Feb 2016 p. 444 – 466

Some Icons from:

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