SenseMyHeart

A Validated Cloud Web-Service

Motivation

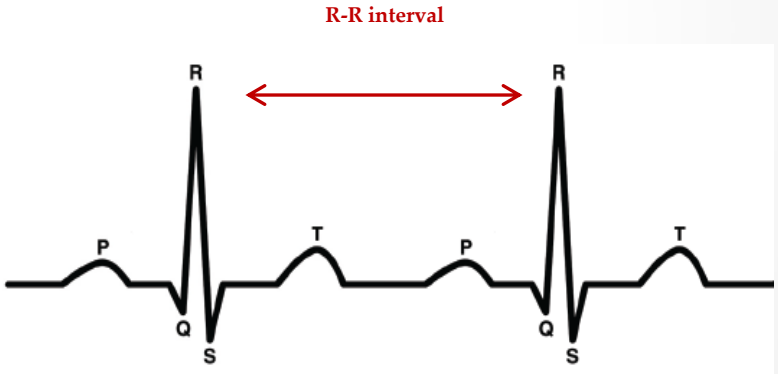
Necessity: Ambulatory monitoring of **stress** and **fatigue!**
(through cardiovascular assessment)

Among **high-risk** professionals

- Policemen (**SCOPE**)
- Bus-Drivers (**Vital-Driver**)
- First-Responders (**Vital-responder**)

But also for **citizens** of a **'Future City'**

Heart rate variability and **cardiovascular intensity** are useful tools! [1,2]



[1] - Nickel, P.; F. Nachreiner (2003). "Sensitivity and Diagnostics of the 0.1-Hz Component of Heart Rate Variability as an Indicator of Mental Workload". *Human Factors* **45** (4): 575–590.

[2] - Jönsson, P. (2007). "Respiratory sinus arrhythmia as a function of state anxiety in healthy individuals". *International Journal of Psycho-physiology* **63** (1): 48–54.

HRV Measures

Relative measure of data quality: [3]

NN/RR – fraction of total RR intervals that are classified as normal-to-normal

Commonly used **time-domain** short-term measures:* [3]

AVNN	Average of all NN intervals
SDNN †	Standard deviation of all NN intervals
rMSSD †	Square root of the mean of the squares of differences between adjacent NN intervals
pNN50	Percentage of differences between adjacent NN intervals that are greater than 50 ms

† - Links to stress have been reported in Literature.

* - Presented as last seen at http://www.physionet.org/tutorials/hrv-toolkit/, of 11th November 2014

[3] - Goldberger AL, Amaral LAN, Glass L, Hausdorff JM, Ivanov PCh, Mark RG, Mietus JE, Moody GB, Peng C-K, Stanley HE. PhysioBank, PhysioToolkit, and PhysioNet: Components of a New Research Resource for Complex Physiologic Signals. *Circulation* **101**(23):e215-e220 [Circulation Electronic Pages;http://circ.ahajournals.org/cgi/content/full/101/23/e215]; 2000 (June 13).

HRV Measures

Commonly used **frequency-domain** short-term measures:*[3]

TOTPWR	Total spectral power of all NN intervals up to 0.04 Hz
VLF	Total spectral power of all NN intervals between 0.003 and 0.04 Hz
LF †	Total spectral power of all NN intervals between 0.04 and 0.15 Hz.
HF	Total spectral power of all NN intervals between 0.15 and 0.4 Hz
LF/HF †	Ratio of low to high frequency power

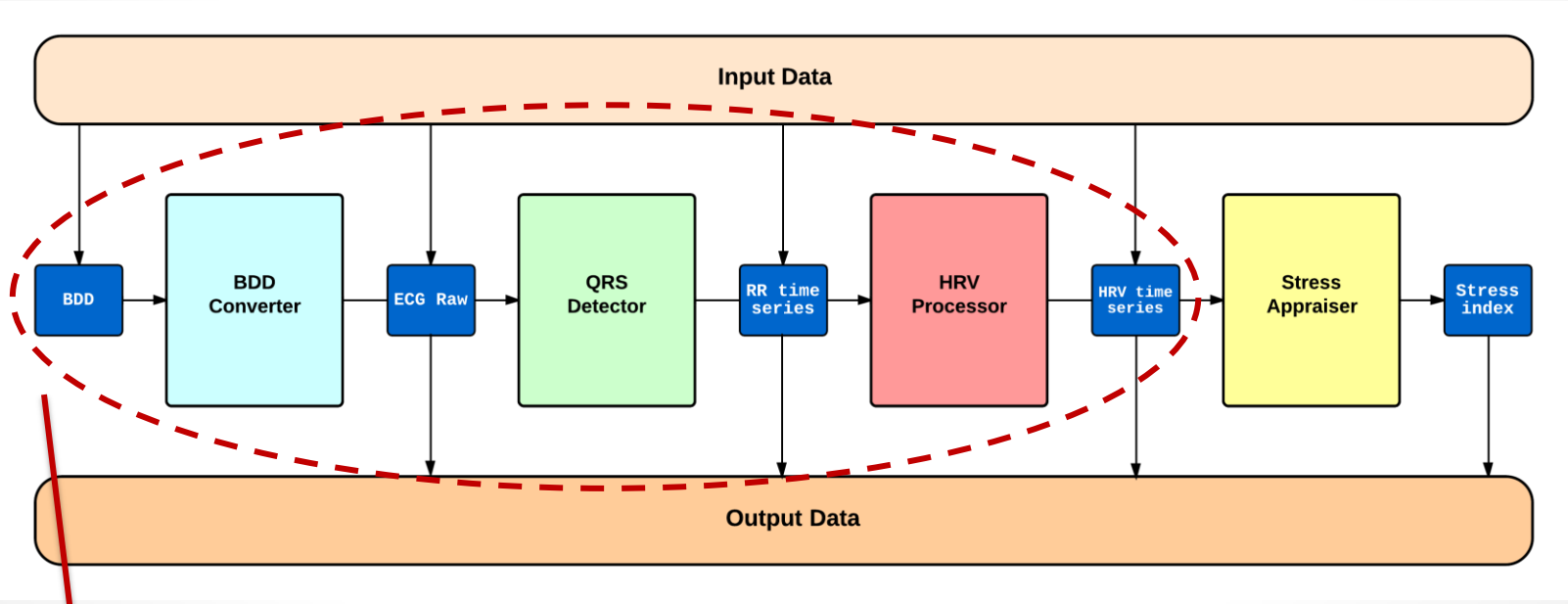
† - Links to stress have been reported in Literature.

* - Presented as last seen at http://www.physionet.org/tutorials/hrv-toolkit/, of 11th November 2014

[3] - Goldberger AL, Amaral LAN, Glass L, Hausdorff JM, Ivanov PCh, Mark RG, Mietus JE, Moody GB, Peng C-K, Stanley HE. PhysioBank, PhysioToolkit, and PhysioNet: Components of a New Research Resource for Complex Physiologic Signals. *Circulation* **101**(23):e215-e220 [Circulation Electronic Pages;http://circ.ahajournals.org/cgi/content/full/101/23/e215]; 2000 (June 13).

SMH Pipeline

- Uses **PhysioNet HRV algorithm** (to expedite deployment) [3].
- Designed to offer **flexibility** to clients (multiple entry and exit points).



Basis for a Stress Assessment Methodology

Validation: Motivation

Issue: PhysioNet algorithms were designed for 12-bit ECG.

Question: What is the impact of using **8-bit** ECG? Is it considerable?

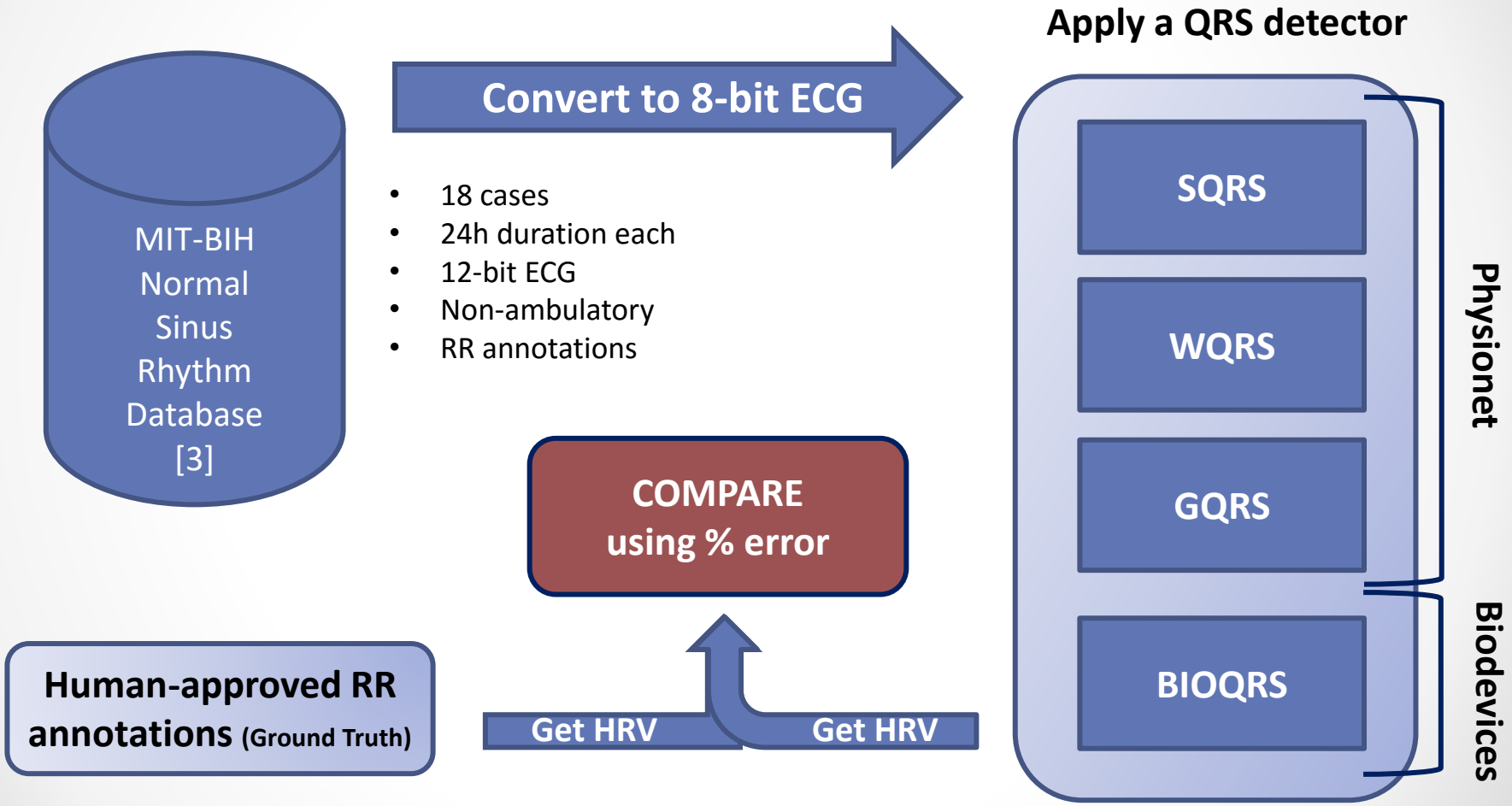
Why 8-bit ECG?

↓

Resolution used by VitalJacket

Hint: It depends on the QRS detector used.

Validation


MIT-BIH Normal Sinus Rhythm Database [3]
Convert to 8-bit ECG
18 cases
24h duration each
12-bit ECG
Non-ambulatory
RR annotations
Apply a QRS detector
SQRS
WQRS
GQRS
BIOQRS
Physionet
Biodevices
COMPARE using % error
Human-approved RR annotations (Ground Truth)
Get HRV
Get HRV

Validation: Results

BIOqrs → **More stability** in exchange for some error %.

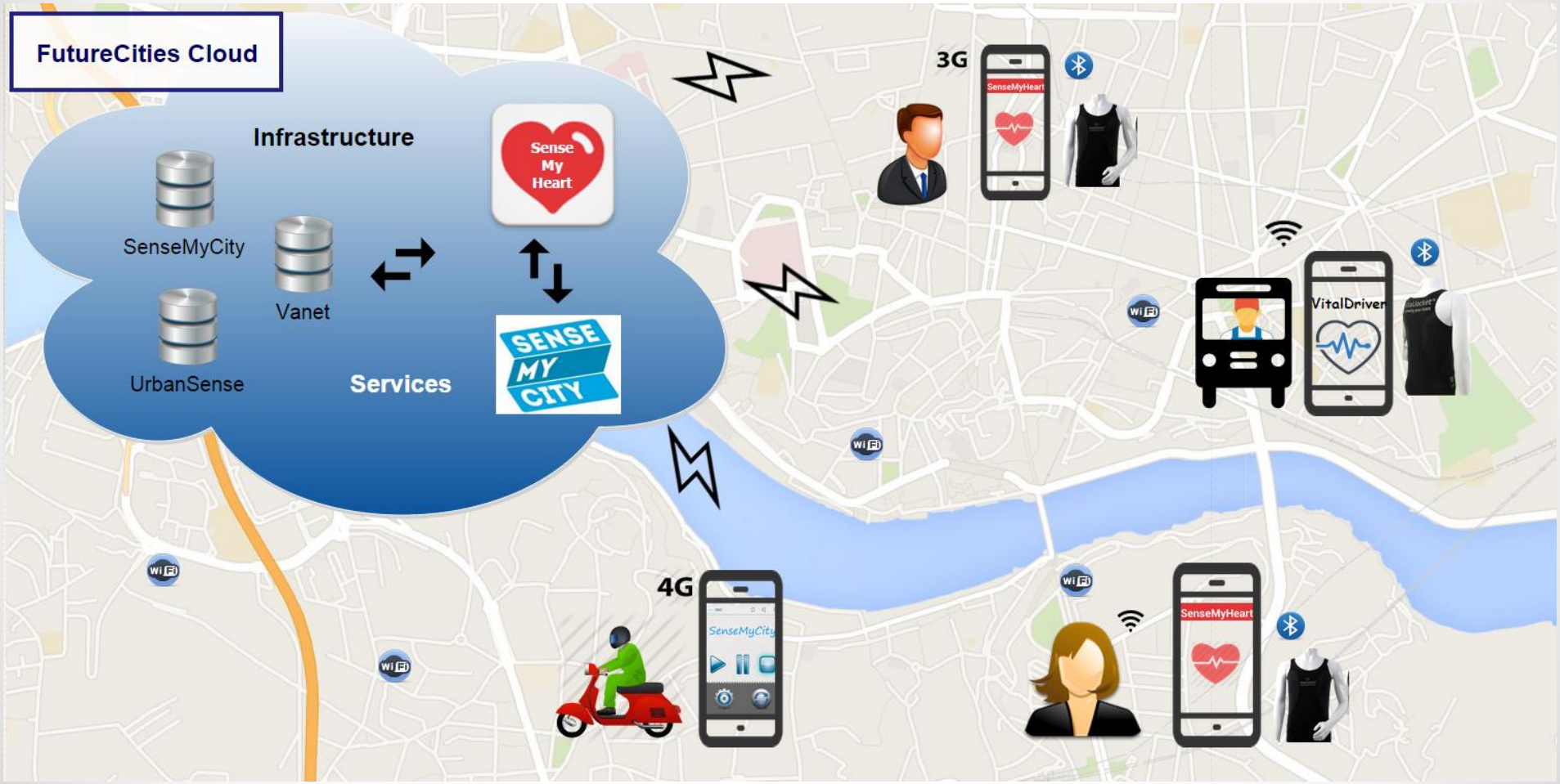
WHY? → It was designed for 8-bit ECG in contrary to other detectors.

	Sqrs	Wqrs	Gqrs	BIOqrs
HRV Average error *	4.2%	3.0%	**2.8%**	**3.4%**
Maximum error	HF pwr	pNN50	pNN50	pNN50
Minimum error	avnn	avnn	avnn	avnn
# NN/RR < 80% **	1	2	**3**	**0**

* - Percentage of error in relation to HRV acquired from human approved RR annotations

** - Out of 18 cases total, each with 24h of duration, taken from the MIT-BIH NSR Database [3].

Application Scenario



Service Address

http://avenue.fe.up.pt

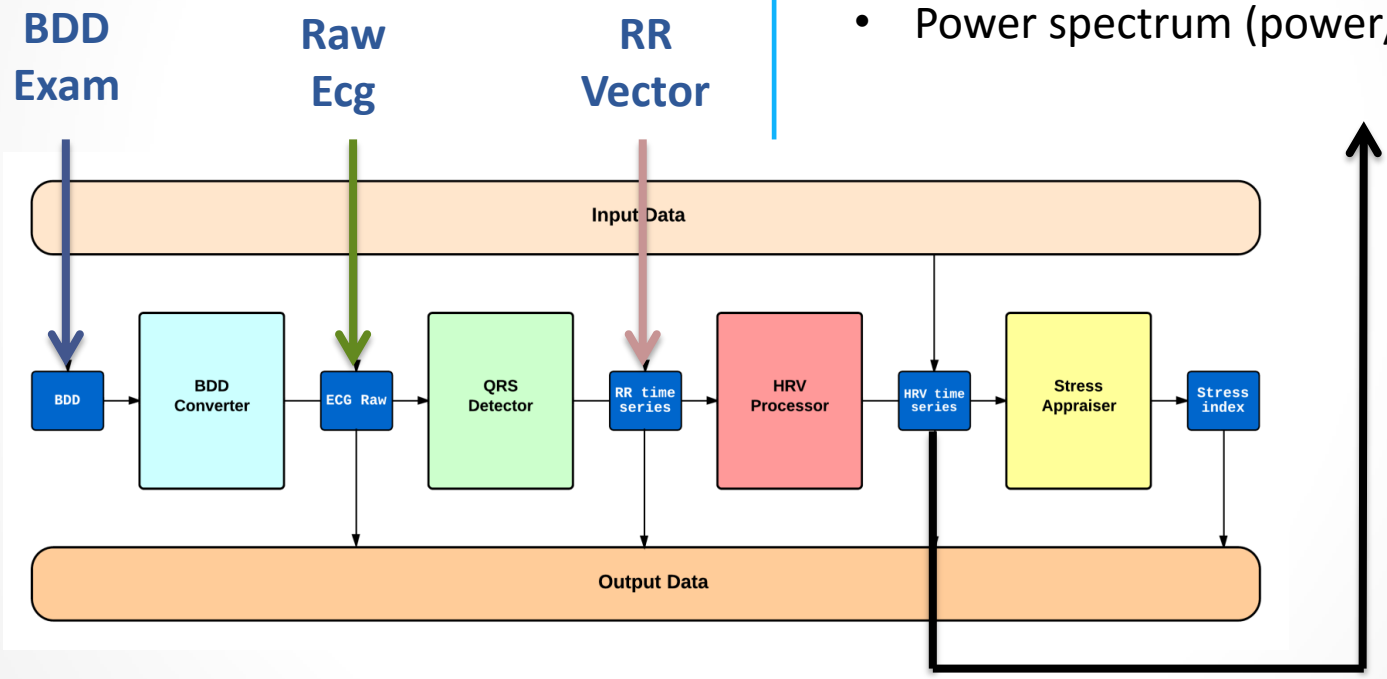
- Try it on your **browser**!
- You will get the service's interface **description file** (WSDL file).

SMH API (so far)

3 entry points
(depending on data type)

1 exit point (returns)

- HRV measures
- Cardiovascular intensity (%/s)
- Power spectrum (power/Hz)

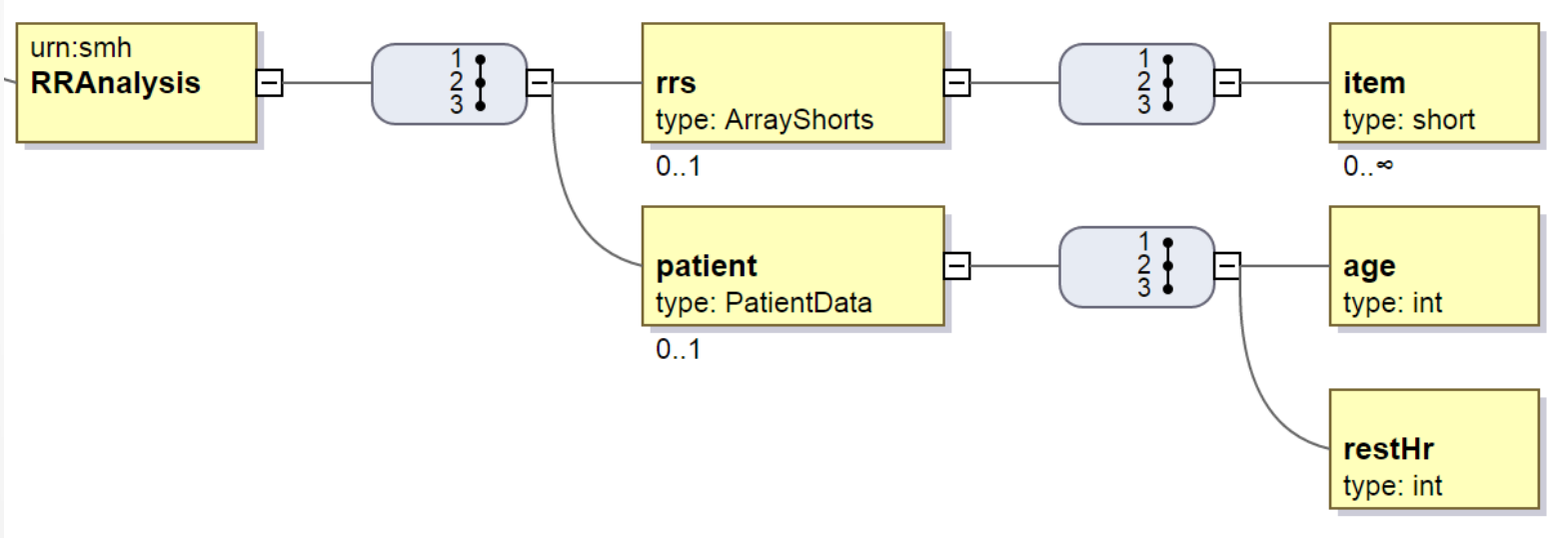


Aimed at short term recordings.

SMH API (so far)

Schema Data Model (not the best naming strategy…):

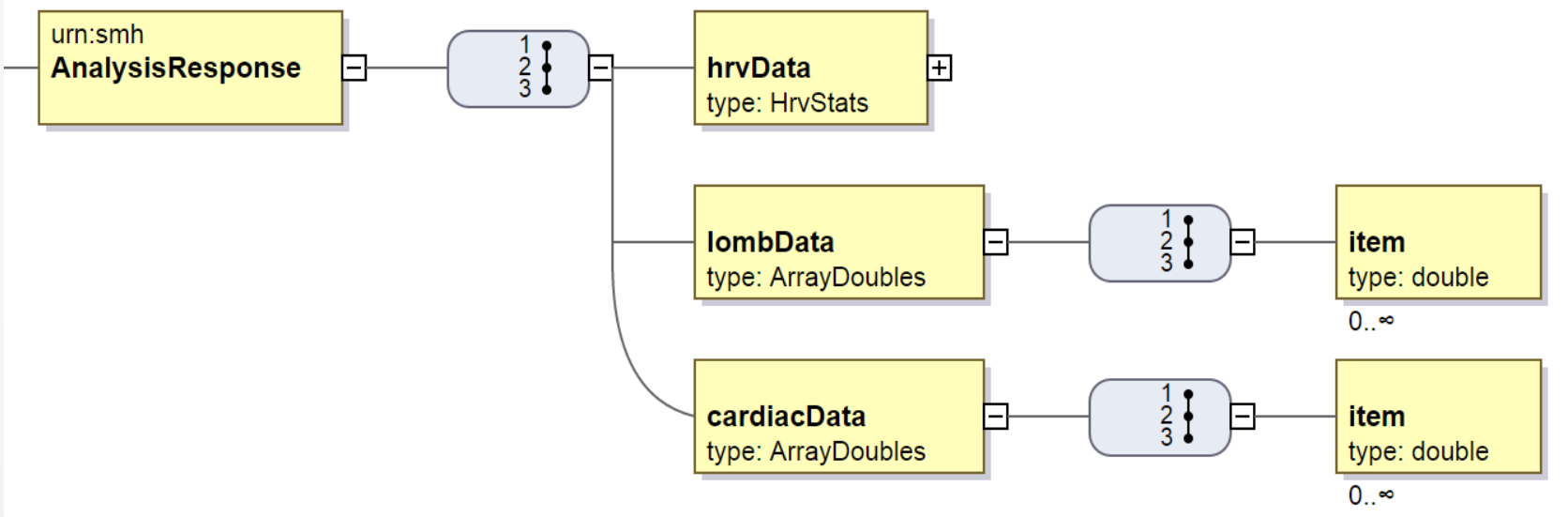
RRAnalysis: function to perform analysis of a RR Exam



SMH API (so far)

Schema Data Model (not the best naming strategy…):

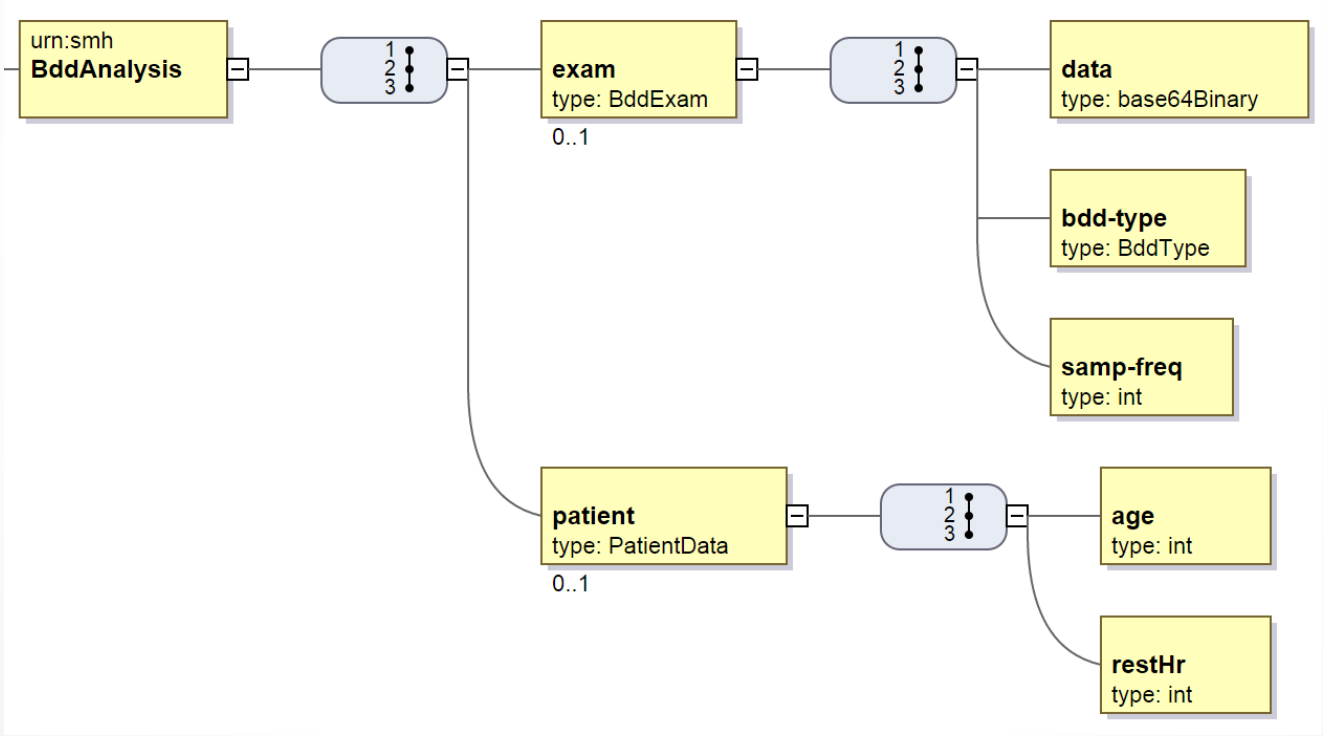
AnalysisResponse: wrapper for returned data



SMH API (so far)

Schema Data Model (not the best naming strategy…):

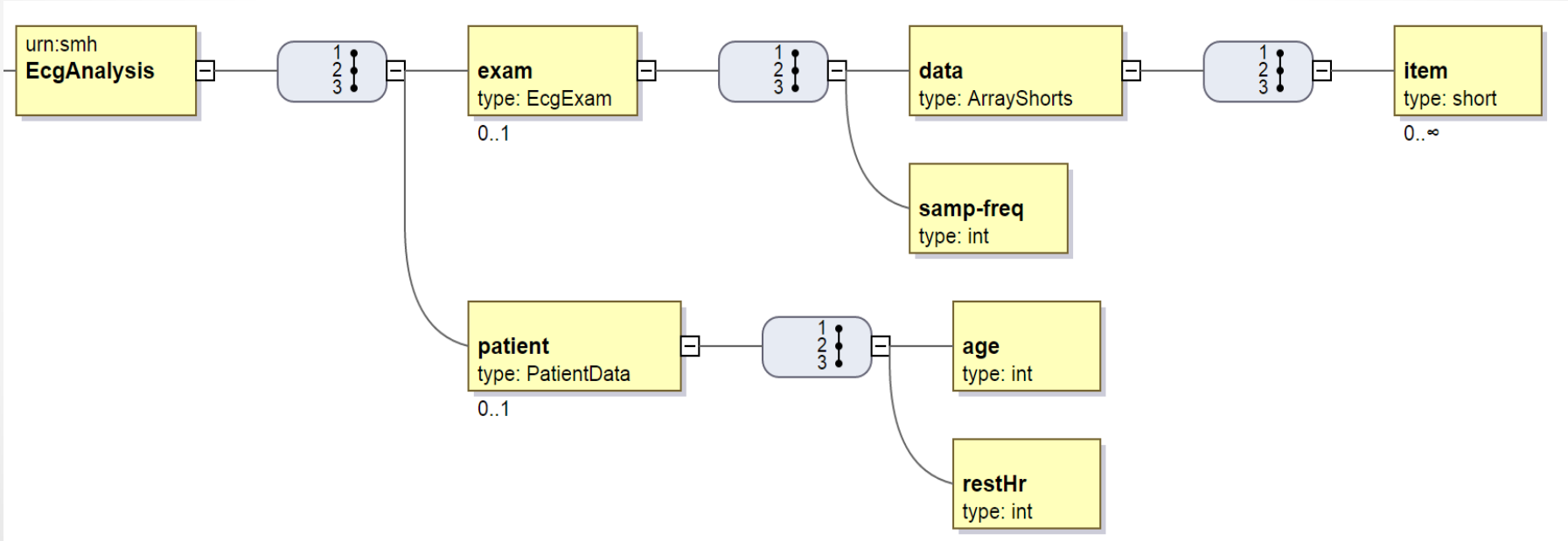
BddAnalysis: function to perform analysis of a Bdd Exam



SMH API (so far)

Schema Data Model (not the best naming strategy…):

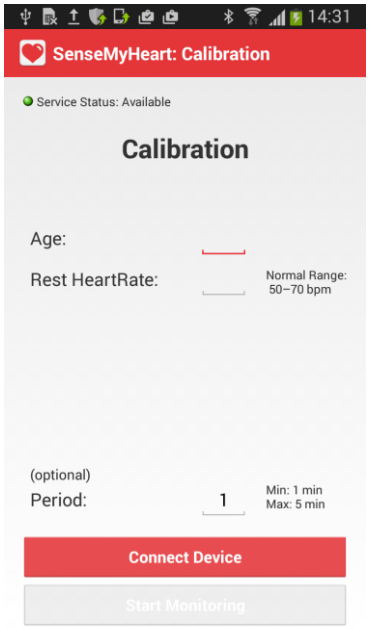
EcgAnalysis: function to perform analysis of a Ecg Exam

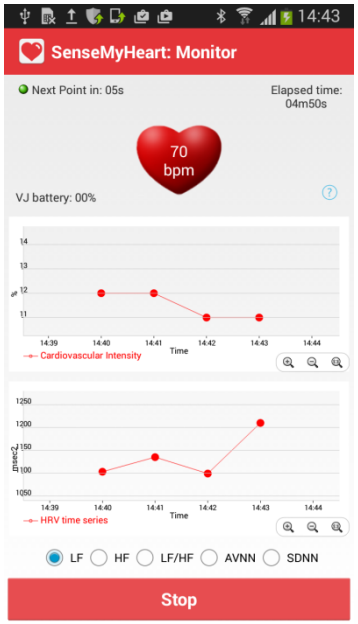


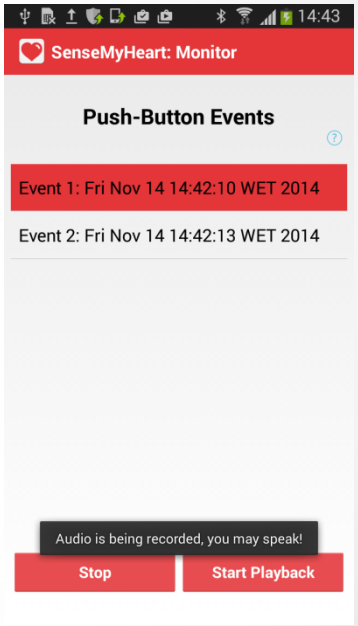
Android App

2 Activities:

- Calibration
  - Parameters for computing Cardiovascular Intensity (CI)
- Monitor
  - CI and HRV time series graphs
  - Instantaneous heart rate
  - Push-Button events







Android Demo

http://youtu.be/cikNlXsdrHs

Future Directions

- New **API** (**REST**?) for **long exams** (≈ 24h).
- **SMH database**?
- **Session**-based Android App with connection to DBs and user history.
- **Stress dataset** based on the Stroop word-color test for training "stress" algorithm.
- Write Paper(s).

[5] - Brosschot, J.F.; E. Van Dijk, J.F. Thayer (2007). "Daily worry is related to low heart rate variability during waking and the subsequent nocturnal sleep period". *International Journal of Psychophysiology* **63**

Thank you!

Pedro Manuel Pinto da Silva
João Paulo da Silva Cunha

Contacts: ppintodasilva@fe.up.pt / jpcunha@fe.up.pt