

CoMEHeRe: Co-operative Models for Evidence-based Healthcare Redistribution

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Credit: Getty

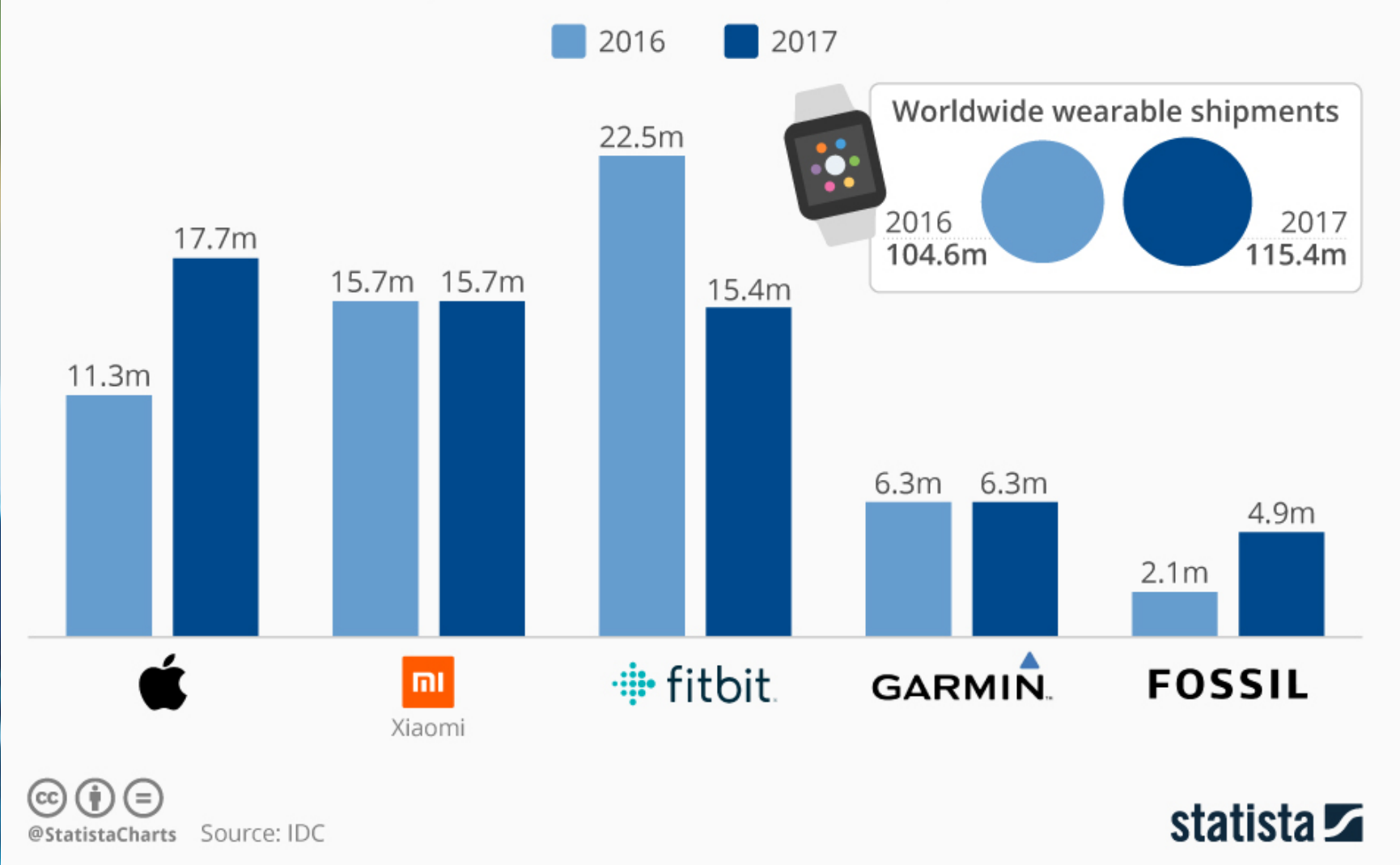


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blockchain.surrey.ac.uk/projects/comehere.html

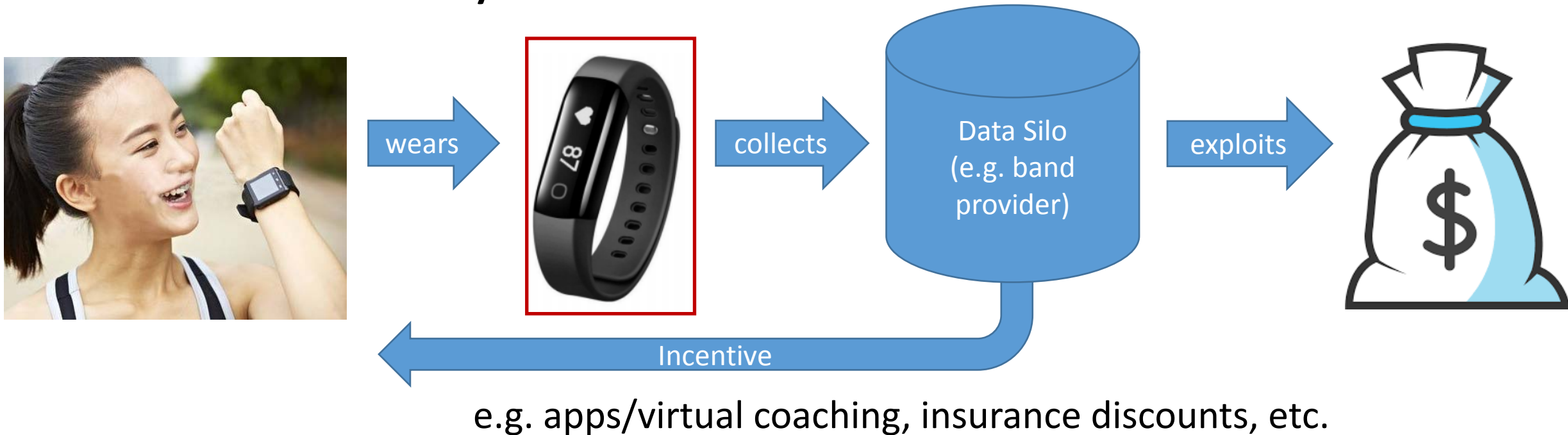
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Rise of the Wearable Bio Sensor (WBS)

- ✓ 325m connected wearable biosensors globally (2017) projected 1bn by 2021
- ✓ Predominantly wrist worn: accelerometer, heartrate, GSV, blood oxygen
- ✓ Data vs. hardware market: data siloed by band provider for exploitation

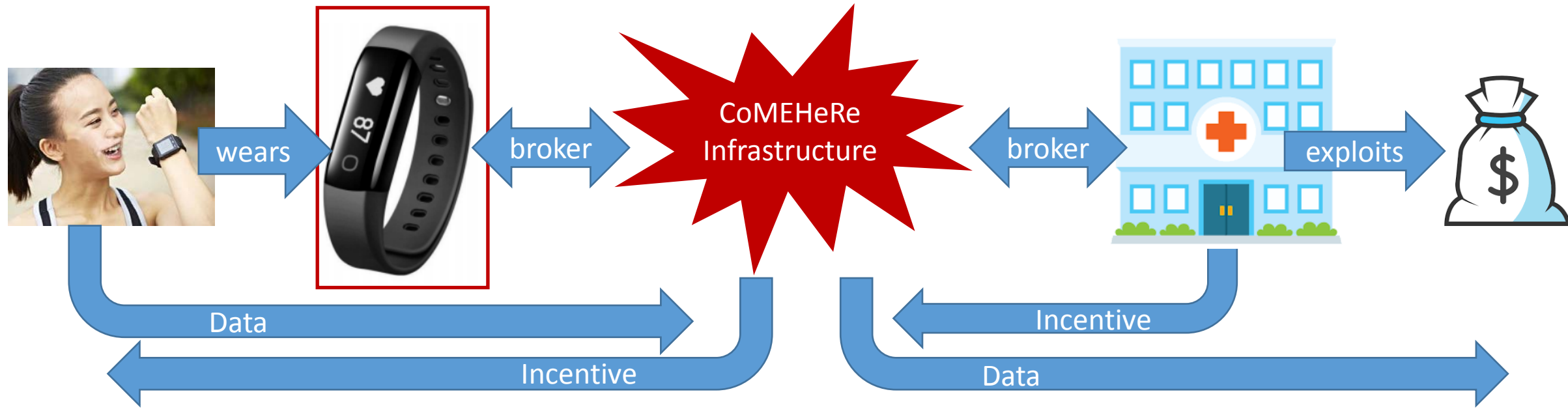
1st Generation Model: Today



Giving users agency over their WBS data

- ✓ CoMEHeRe **gives users agency** over the exploitation of their WBS data
- ✓ Infrastructure **brokers data** to 'consumers' (healthcare providers) with **granular control**

2nd Generation Model: CoMEHeRe



CoMEHeRe brokers data for incentives via Blockchain based infrastructure

CoMEHeRe Project Aim

CoMEHeRe will transform preventative healthcare through Distributed Ledger (Blockchain) technology for commodifying and brokering casually captured personal healthcare data (e.g. from wearable biosensors) to public or private healthcare providers.

Impact

- ✓ **Democratise and commodify personal healthcare data** – user maintains control. No hoarding! (1st generation)
- ✓ **Creative, new sustainable business models** for preventative healthcare created
- ✓ **Auditable chain of evidence** for public health research and epidemiology
- ✓ **Disruption of actuarial science** towards real-time –potential to detect early conditions for pre-therapeutic benefit
- ✓ **Crowd-sourced risk management** and **contract negotiation** for particular diseases and conditions

Scope: 30 month project funded by the UKRI Digital Economy Programme (via EPSRC)

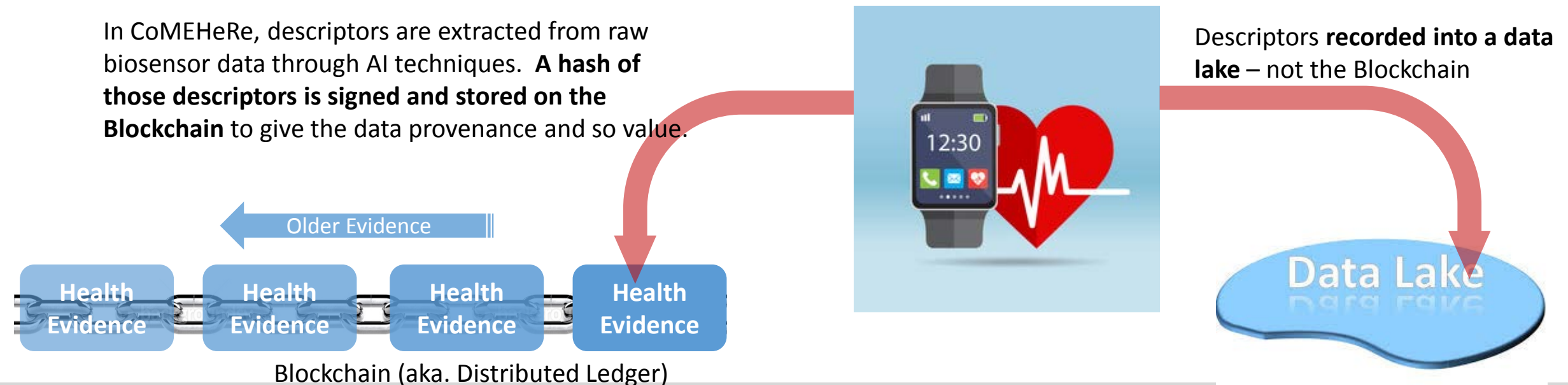


Why Blockchain (Distributed Ledger) ?

A **Blockchain** is a way of **storing data** (a kind of database) with unique properties:

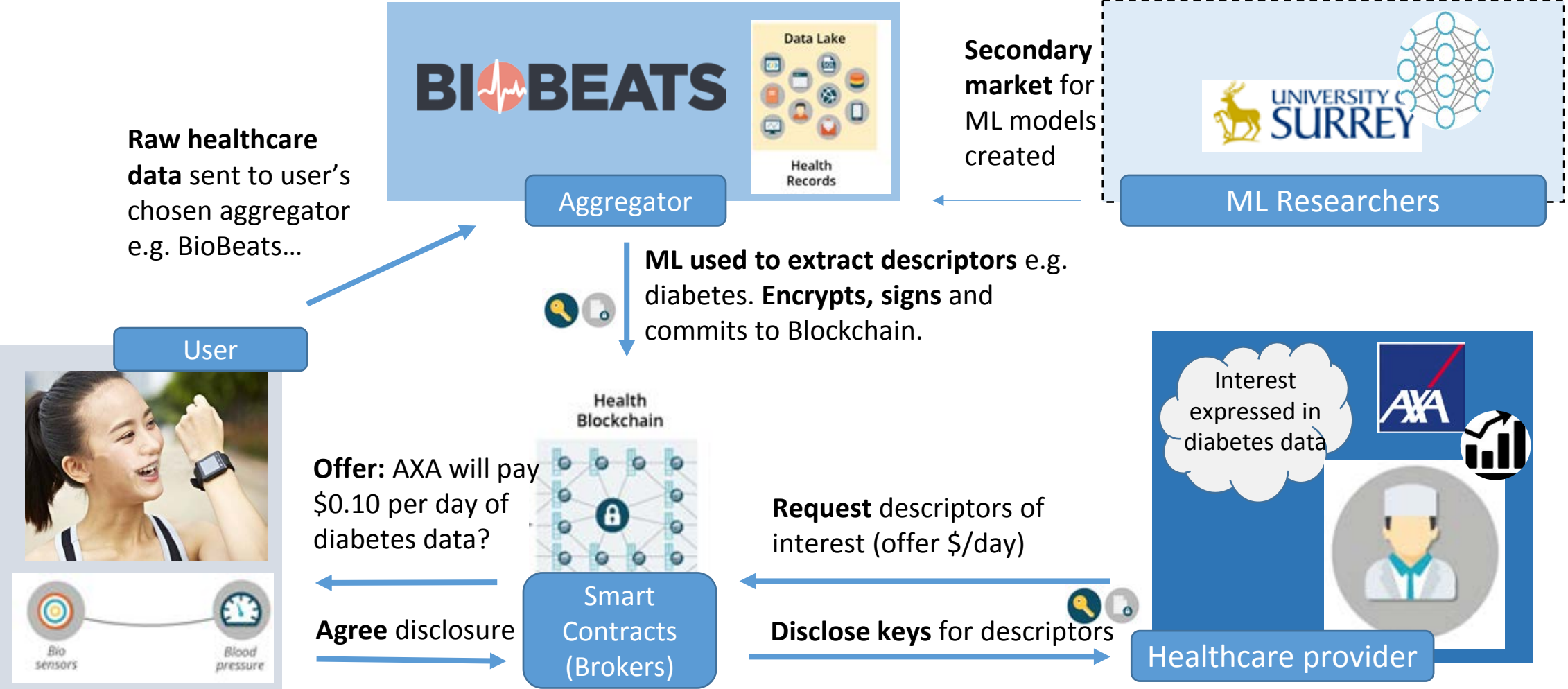
- ✓ It can **guarantee the provenance of data** within it (**tamper-proof data**)
- ✓ Those guarantees are made **without reliance on a centralised authority**

Data is stored in '**blocks**'. Each block contains a **hash** of the **previous block**. Combined with consensus checking this makes it intractable to modify blocks



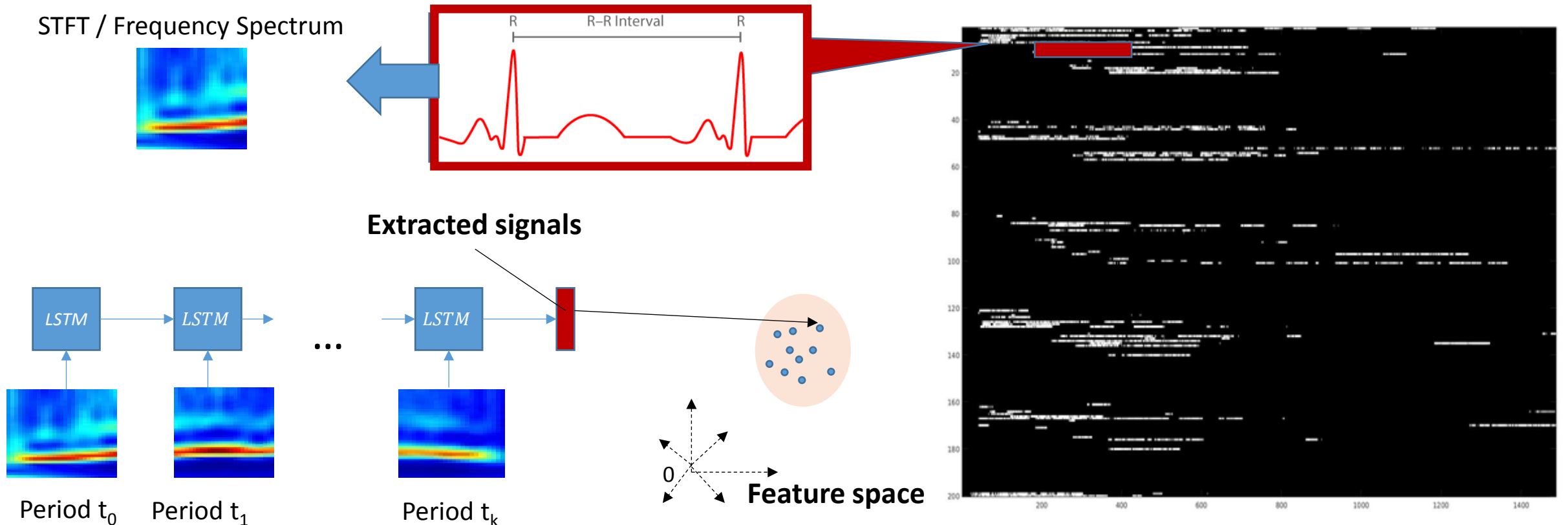
CoMEHeRe Infrastructure

Smart contract on Ethereum brokers signals derived via AI from wearable biosensor data



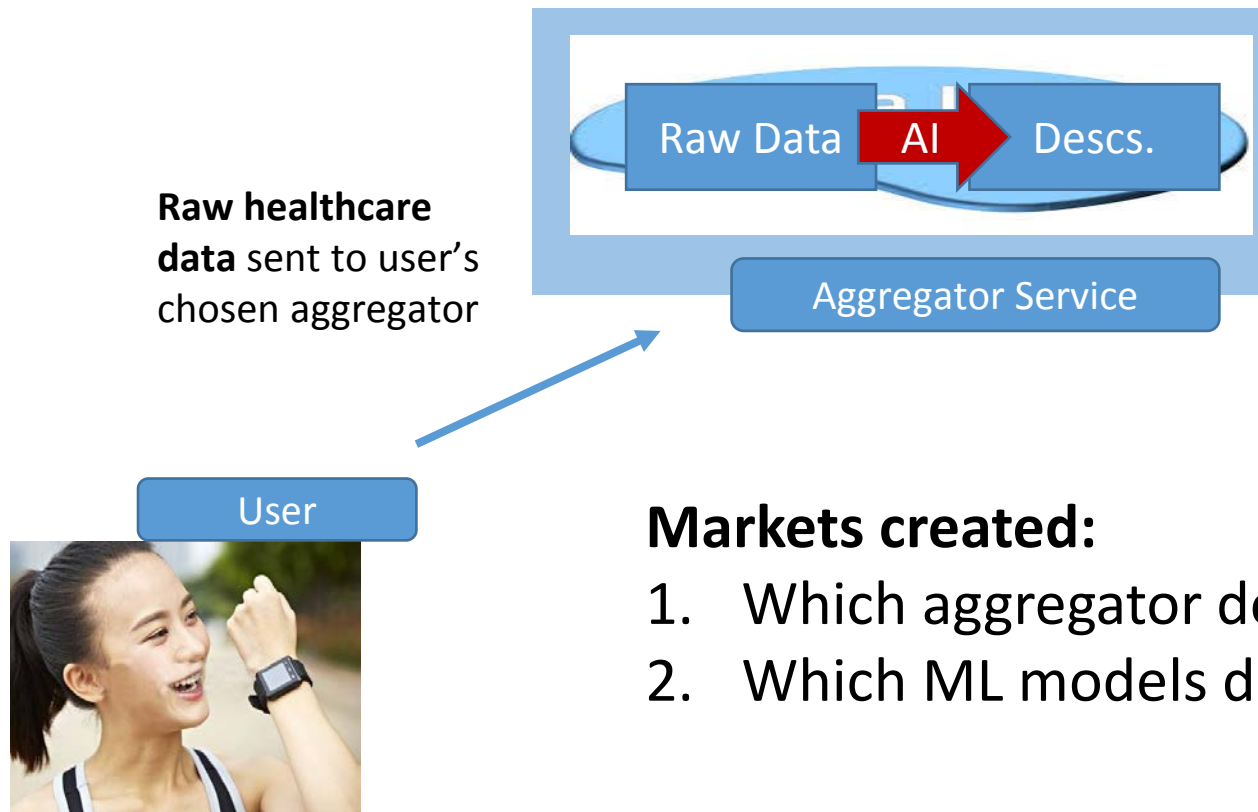
Extraction of signals via deep learning

- ✓ Deep neural network used to extract signals from raw WBS data stream
- ✓ Inter-beat Interval (IBI) / R-R Variability
- ✓ Short-term Fourier Transform (STFT) computed over 30 minute sliding time window
- ✓ LSTM processes STFT sequence to extract descriptors (health evidence)



Use Case - Walkthrough

- ✓ Raw data is gathered from WBS, encrypted and uploaded to the Cloud via mobile.
- ✓ Cloud based aggregator collects this raw data, storing it securely within a private data lake
- ✓ AI distils high level health descriptors e.g. related to exercise and cardio function.

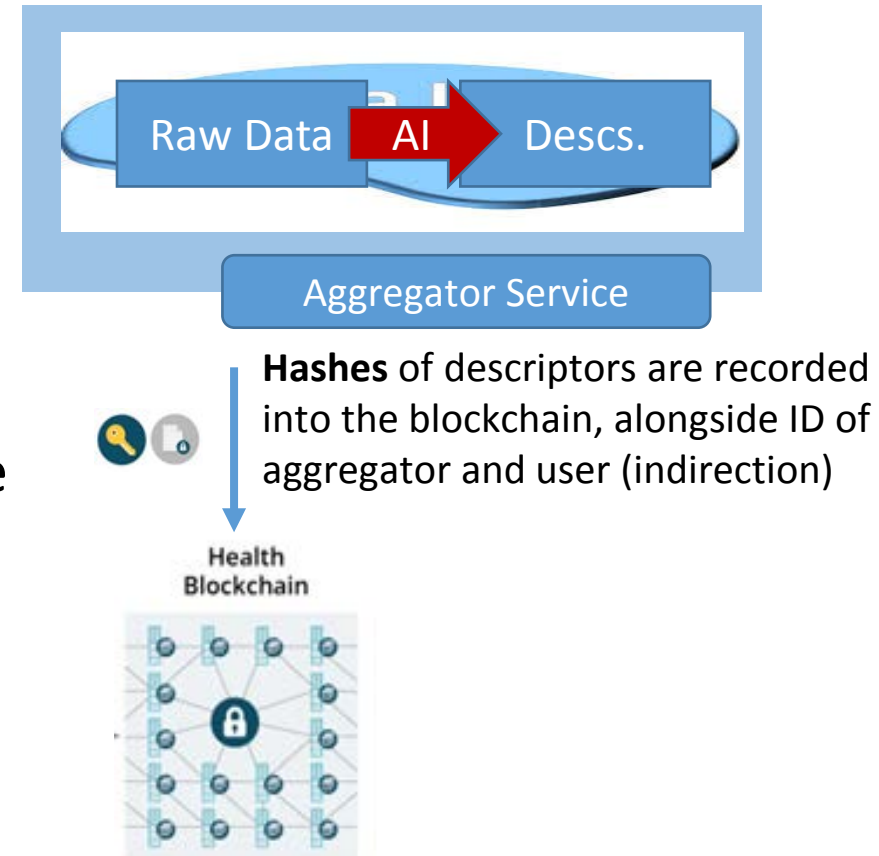


Markets created:

1. Which aggregator does the user pick?
2. Which ML models does the aggregator use? (may inform 1)

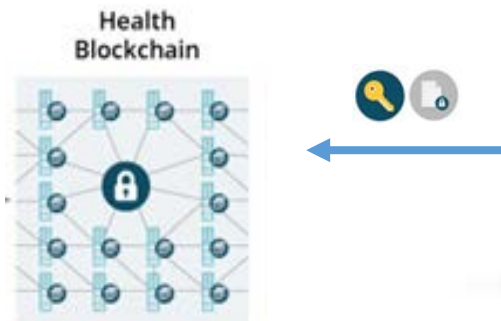
Use Case - Walkthrough

- ✓ Multiple users send data to the aggregator and their descriptors are encrypted with user-specific keys and committed into the CoMEHeRe blockchain
- ✓ Block mined under a proof-of-work system (gas spent)
- ✓ No descriptors placed on Blockchain – only hashes
- ✓ Hashes are cryptographically signed by Aggregator
- ✓ GDPR: user opt-out by removing data from lake at any time



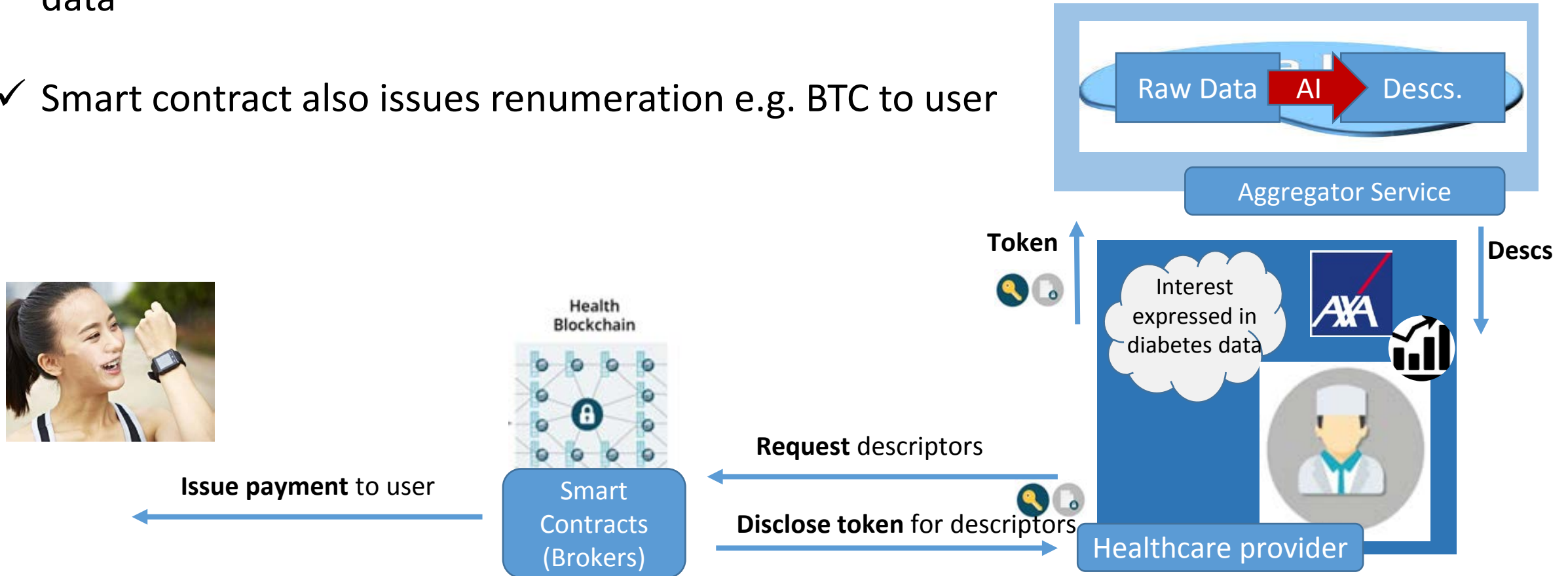
Use Case - Walkthrough

- ✓ Healthcare provider e.g. AXA interested in cardiac health e.g. for the purposes of modelling risk in the users' demographic group
- ✓ AXA requests such data from several hundred participants active on the CoMEHeRe
- ✓ Request is signed and submitted to platform, causing the broker to issue a contract offer that flashes up on users' mobile devices.
- ✓ User accepts by signing AXA's request and committing it to Blockchain via Ethereum smart contract



Use Case - Walkthrough

- ✓ AXA can now issue requests to smart contract using user's signed response as access token
- ✓ Smart contract returns access token which can be presented to Aggregator in exchange for data
- ✓ Smart contract also issues remuneration e.g. BTC to user




Trial of Initial Prototype

- ✓ CoMEHeRe prototype trialed at University of Surrey ~100 students given wearables
 - Trial ran 11/1/18 to 12/2/18 during the examination period
- ✓ Users periodically asked to complete questionnaires on **perceived stress levels**
 - STAI and DASS-21 used
- ✓ Questionnaire data used to train deep learning model to extract stress descriptors
- ✓ Able to detect acute stress events (exams) to 70% accuracy

• FFT Data – 0 to 0.5 Hz (in 0.005 Hz increments)

	Data Size			Accuracy	
	Train	Test	Validation	No Pre-training	Pre-training
Day vs Night Only	2971	372	371	73%	N/A
Day Data	653	81	82	67%	70%
Night Data	653	81	82	62%	68%

BIOBEATS 

Student Participants Required


To explore the use of novel:

- healthcare data sharing methods
- machine learning based analysis of healthcare data

What: Recording participant's activity and heart rate and stress levels over the exam period using a device similar to a Fitbit

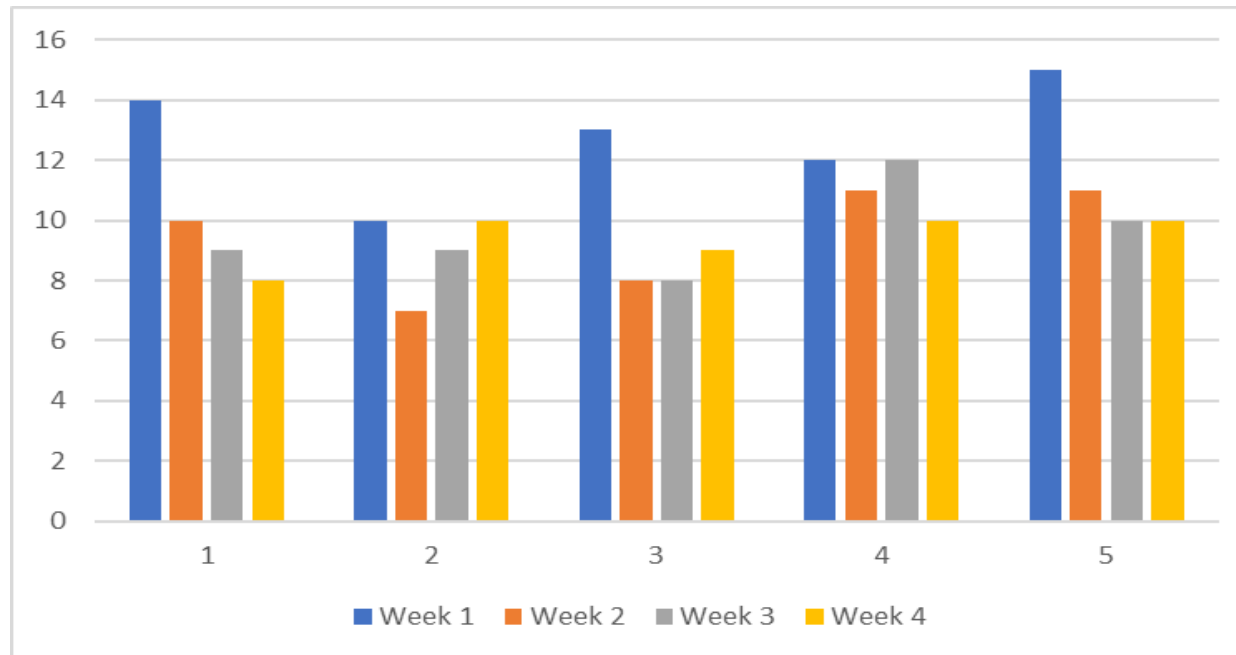
Why: This research will aid future design of healthcare, by improving how individuals may benefit from collection and control of their personal health data. You can keep the wristband when the study finishes, if you wish

When: Drop-in to *for a one hour sign-up session any time Monday – Friday between*



Limitations of Initial Trial

- ✓ Dynamics of market not evaluated – single ‘provider’ (us) contracted in at start
- ✓ Additional offers issued to students were dummies, to test reaction to pricing.
- ✓ All users incentivized with voucher reward for participation – not micropayments



Conclusion

- ✓ CoMEHeRe is 6 months in to its 30 month roadmap
 - Initial technical prototype built and trialed with 100 participants
 - Socio-economic models still need to be specified and tested
 - We plan 2 further trials, another campus based (12 months) and a public trial (24 months)
- ✓ Deep Learning / AI promising for extraction of stress / wellbeing descriptors
 - We will explore other forms of healthcare descriptor e.g. cardio
- ✓ Ethereum based prototype
 - Promising start, but interaction model is user-centric not yet data-centric
 - How can we implement micropayments via the contract (low cost high volume, not BTC!)

Please share your feedback and thoughts with us!

CoMEHeRe: Co-operative Models for Evidence-based Healthcare Redistribution

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Credit: Getty

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