

# Blockchain in the e-health era

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# PROBLEMA GENERALE

Come condividere sempre più dati medici per scopi diversi con stakeholders conosciuti e non, mantenendo al contempo l'integrità dei dati e proteggendo la privacy dei pazienti



# QUANTO VALE LA PRIVACY

“i tuoi dati medici valgono 10 volte di più del tuo numero di carta di credito nel mercato nero”



REUTERS



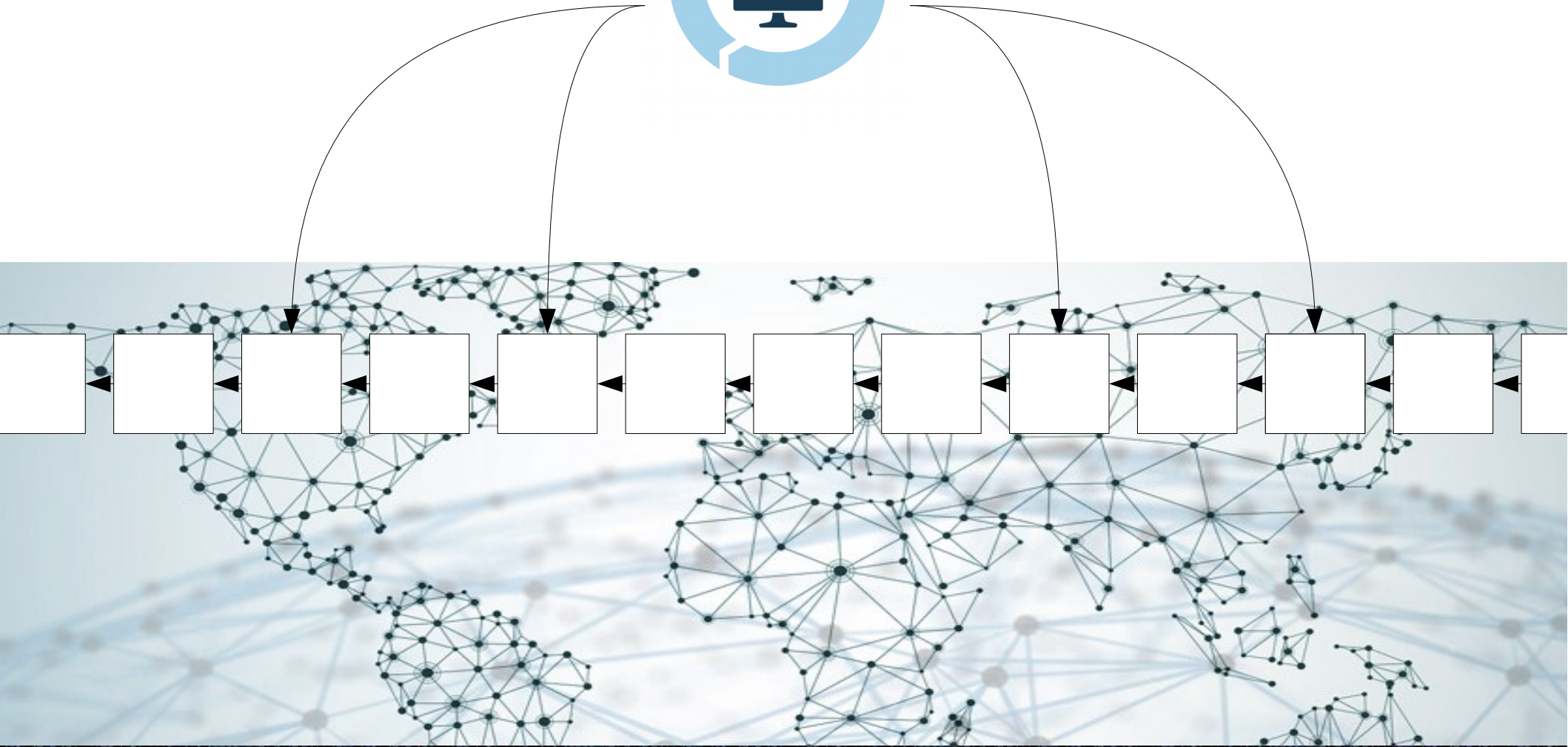
SAPIENZA  
UNIVERSITÀ DI ROMA

“... I Pazienti lasciano i dati dispersi in varie organizzazioni quando gli eventi della vita li portano dal data silo di un organizzazione ad un'altro”

Dr. John Halamka, CIO, Beth Israel Deaconess, Boston, Massachusetts.







## Estonia and Dubai Test Medical Records on the Blockchain

April 10, 2017 • News • Coinify



We live in a digital world, yet the majority of medical records such as blood test reports or x-rays are stored on paper. Moreover, most hospitals don't share access to medical records, which is time consuming for doctors when prescribing treatments and inconvenient for patients. Having medical records on the blockchain can have a positive

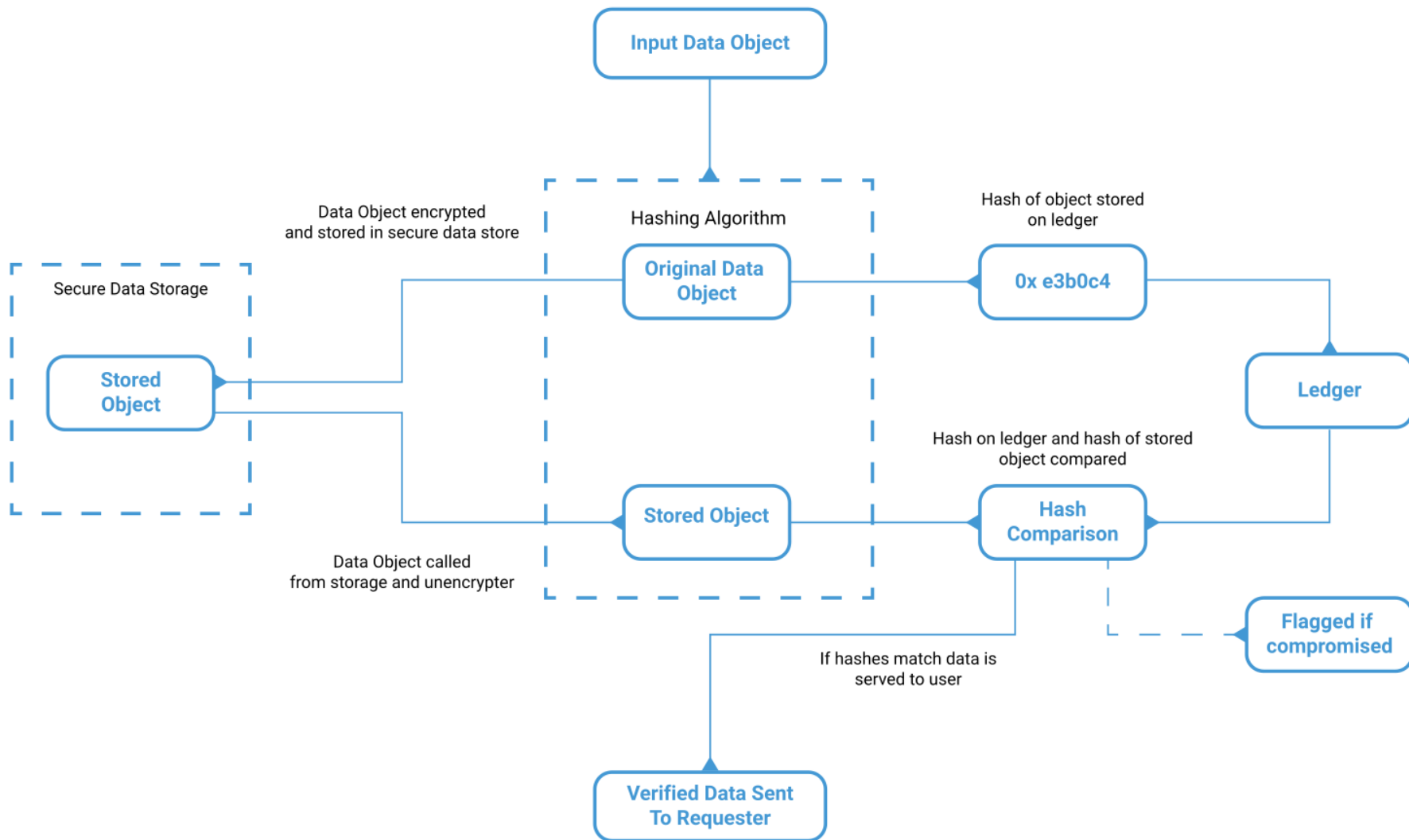
# Multi player recenti

- Blockchain enabled electronic health record (EHR) – offchain secure data storage
- Token per incentivare un comportamento corretto e comprare servizi

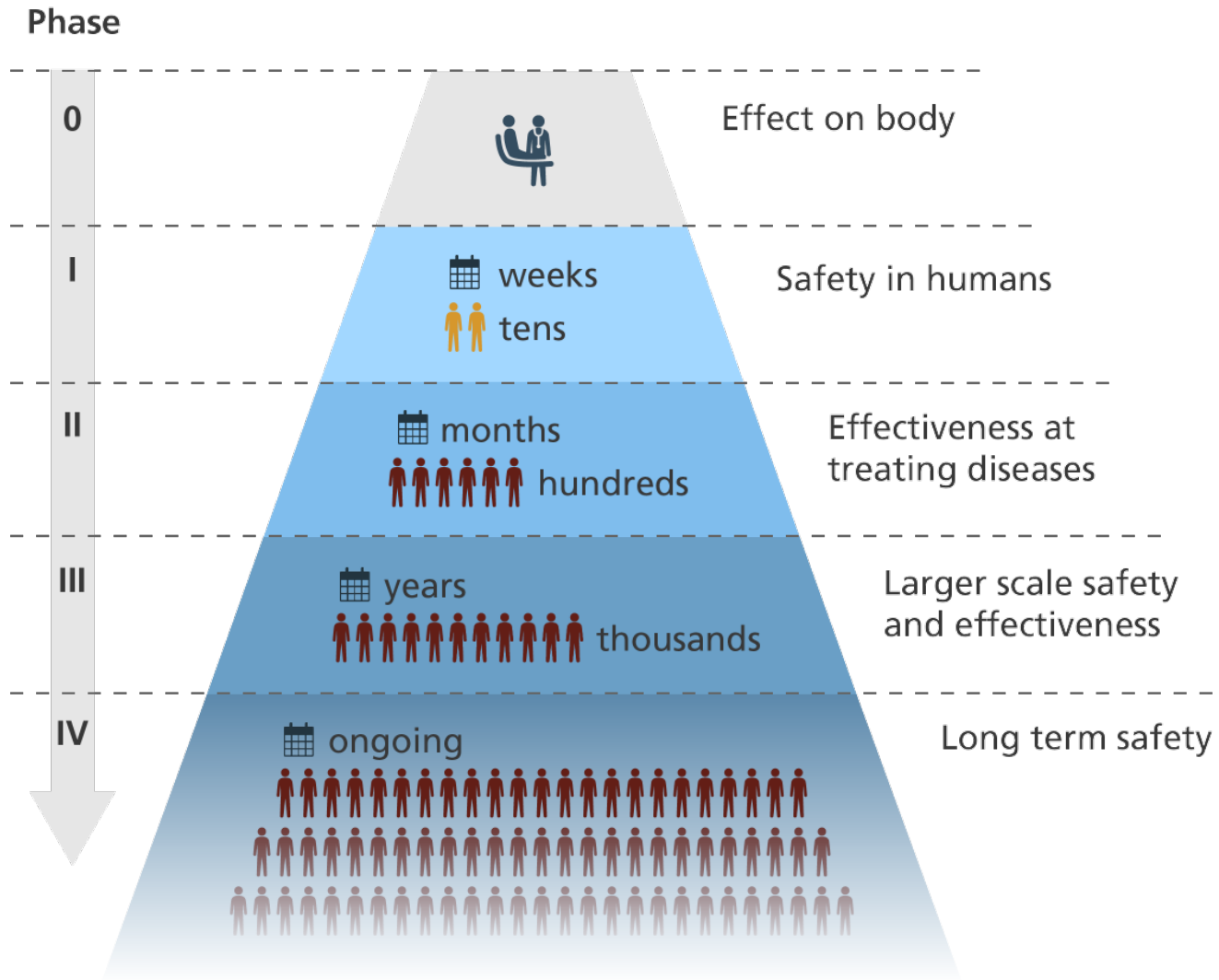




# A “standard” solution – offchain secure data storage



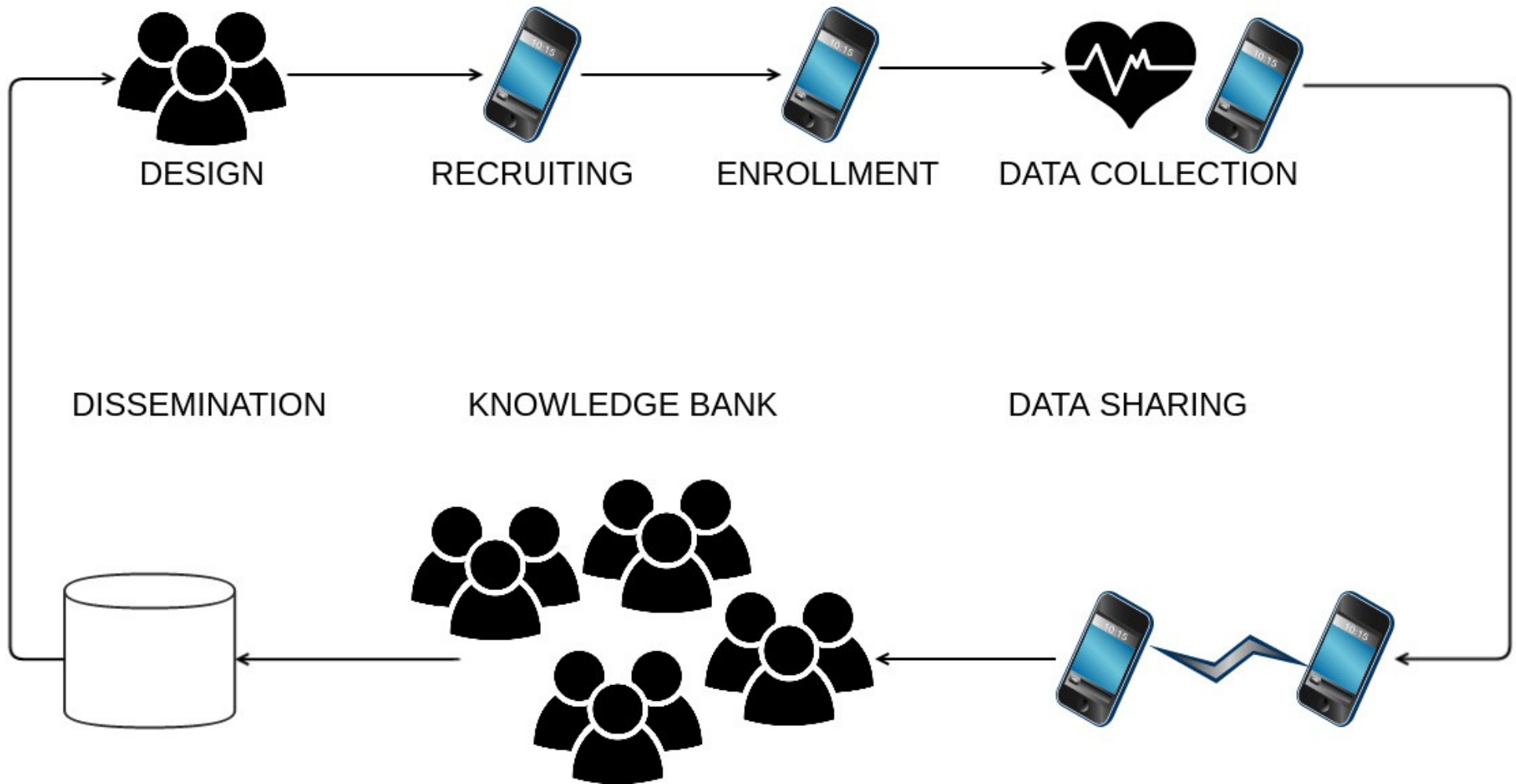
# Clinical Trial



 healthy  affected



# Digital Clinical Trial



# (UN) PROBLEMA SPECIFICO

Come raggiungere una massa critica di individui,  
caratterizzarla e proporre il reclutamento agli  
individui eleggibili

... mantenedo al contempo  
l'integrità dei dati e  
proteggendo la loro privacy



The screenshot shows the top of a research article page on F1000Research. The header is orange with the F1000Research logo and the tagline 'Open for Science'. A search bar is in the top right. Below the header is a navigation menu with links for BROWSE, GATEWAYS, HOW TO PUBLISH, ABOUT, and BLOG. A 'Check for updates' button is on the right. The article title is 'Blockchain protocols in clinical trials: Transparency and traceability of consent [version 1; referees: 1 approved, 1 not approved]'. The authors listed are Mehdi Benchoufi, Raphael Porcher, and Philippe Ravaud. There are expandable sections for 'Author details' and 'Grant information'. A box at the bottom of the article states: 'This article is included in the All trials matter collection.' with a small image of colorful pills.



## Abstract

# La soluzione attuale più comune

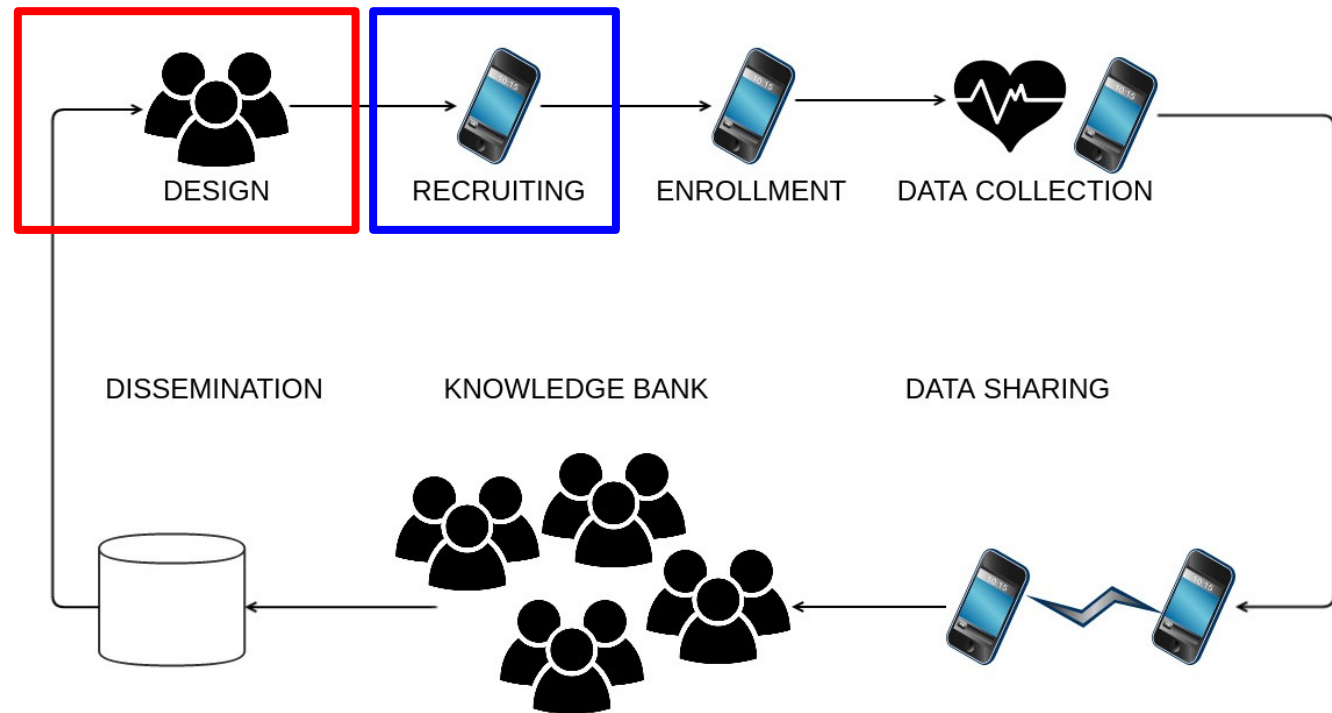
Si cerca pazientemente “a mano” tra i propri  
pazienti



# Focus su desing e recruiting

## Reclutare Individui

Caratterizzare la popolazione

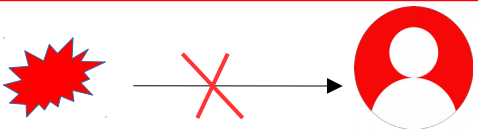


**ASSUNZIONE:** I pazienti sono ben disposti a divulgare I propri dati a coloro che possono aiutarli se percepiscono un valore.

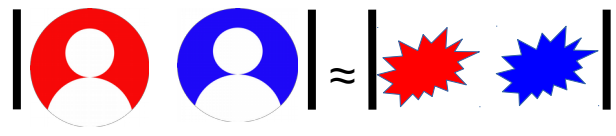


# Approccio

$h$  non invertibile



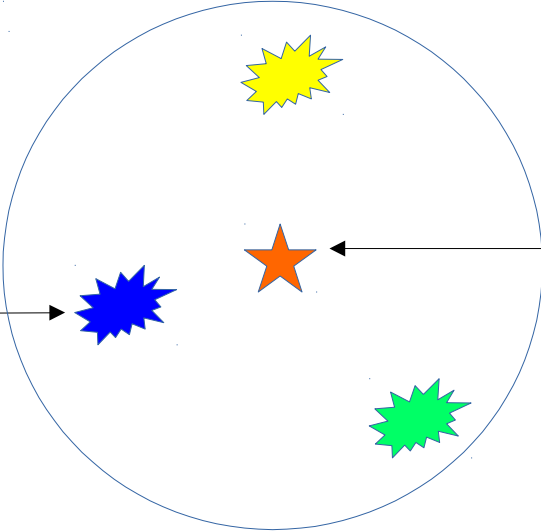
$h$  preserva alcune metriche



$h(\text{red person icon})$

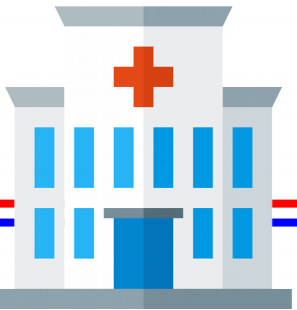


$h(\text{blue person icon})$



$h(\text{orange person icon})$

Candidato tipo

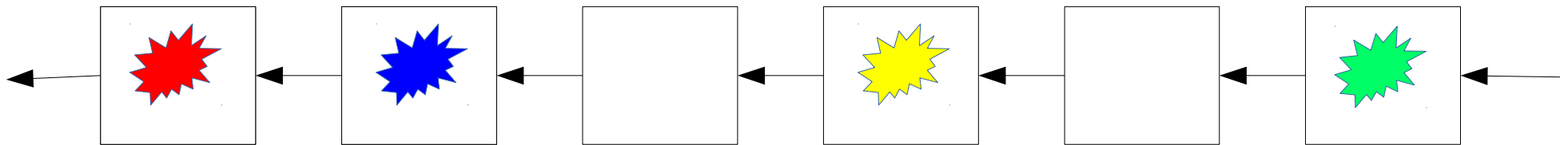


Funzione di Reclutamento booleana  
Viene calcolata nello spazio privato o sulla chain



# PoC

- 16 features
- Dati sintetici, ma realistici sulla base del questionario di reclutamento del Bambin Gesù
- H = random projections

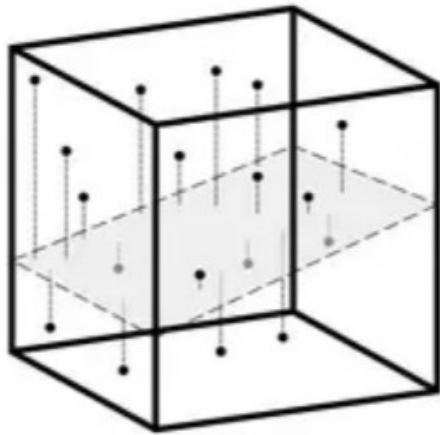


DLT Privato?





Quora

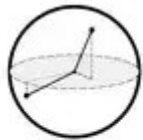


# An Elementary Proof of a Theorem of Johnson and Lindenstrauss

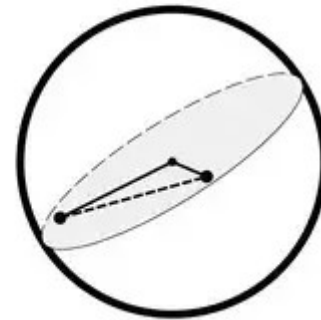
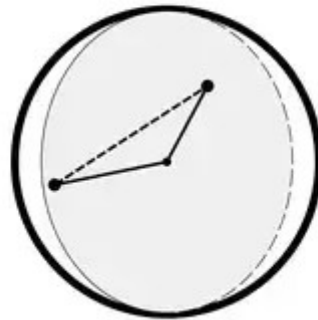
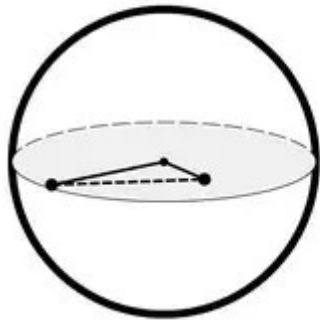
Sanjoy Dasgupta,<sup>1</sup> Anupam Gupta<sup>2</sup>

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projections of the vectors above to random planes  
(note the planes are translated to the origin)



**Theorem 2.1.** For any  $0 < \epsilon < 1$  and any integer  $n$ , let  $k$  be a positive integer such that

$$k \geq 4(\epsilon^2/2 - \epsilon^3/3)^{-1} \ln n. \quad (2.1)$$

Then for any set  $V$  of  $n$  points in  $\mathbf{R}^d$ , there is a map  $f : \mathbf{R}^d \rightarrow \mathbf{R}^k$  such that for all  $u, v \in V$ ,

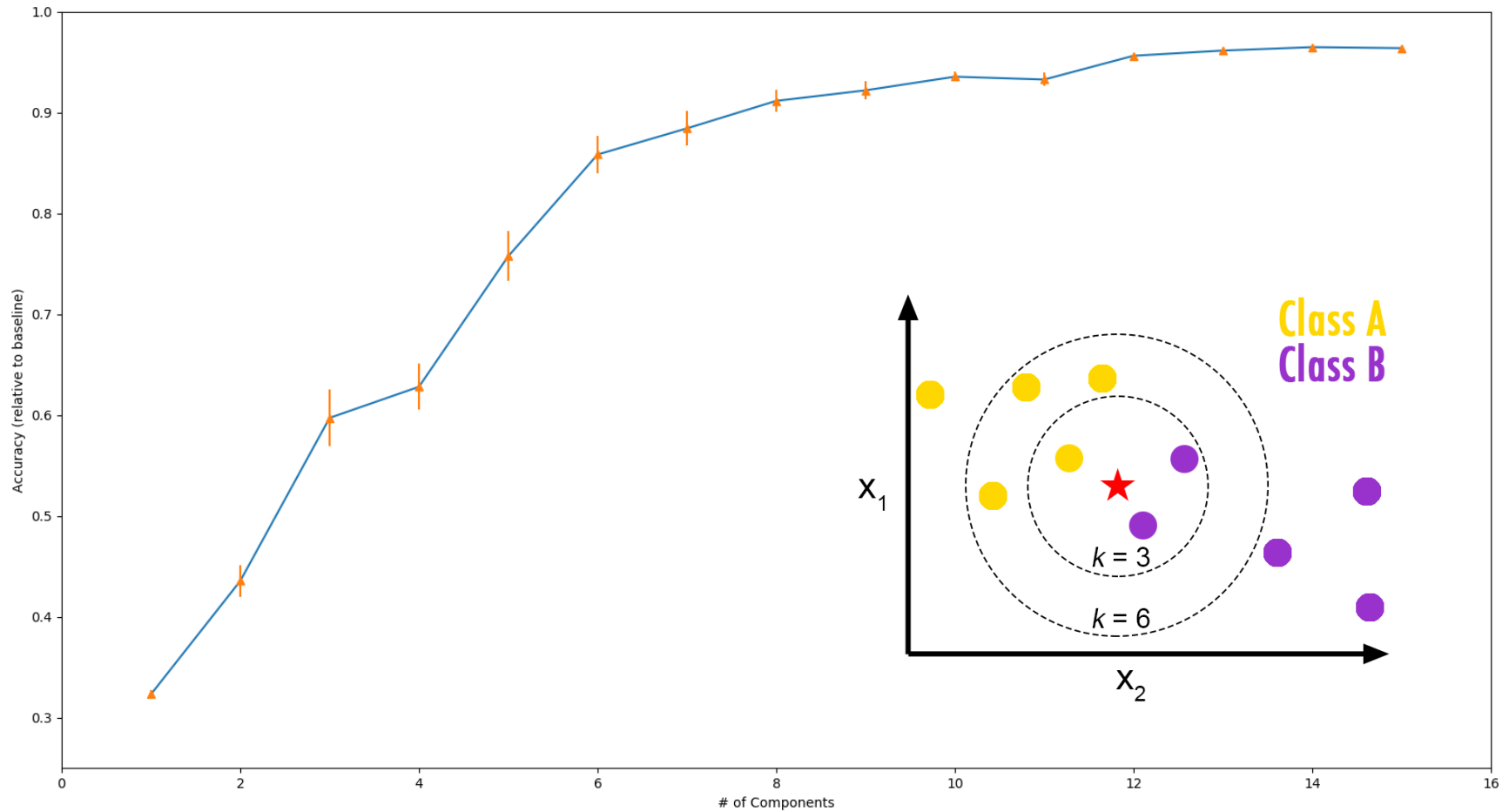
$$(1 - \epsilon)\|u - v\|^2 \leq \|f(u) - f(v)\|^2 \leq (1 + \epsilon)\|u - v\|^2.$$

Furthermore, this map can be found in randomized polynomial time.



# KNN – RND PRJ

Accuracy of Sparse Projection relative to baseline



# Conclusioni e lavori futuri

- PoC elaborato sulla base di una collaborazione col Bambin Gesù
- I test coi pazienti richiedono la definizione di un protocollo che stiamo preparando
- Molte questioni tecniche aperte
  - Quale DLT
  - Implementare la recruiting function su DLT
  - Estendere alle fasi successive del digital trial
  - Gestione di dati incrementali
  - Considerare altre h
  - Modifica dello stato del paziente
  - Mantenere l'anonimato
  - Off-chain

