12ª conferenza nazionale di statistica

PIÙ FORZA AI DATI
UN VALORE PER IL PAESE

LABORATORIO NUMERACY

How Statistics changes In the BIG DATA era?

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FENStatS

ESAC
European Statistical Advisory Committee

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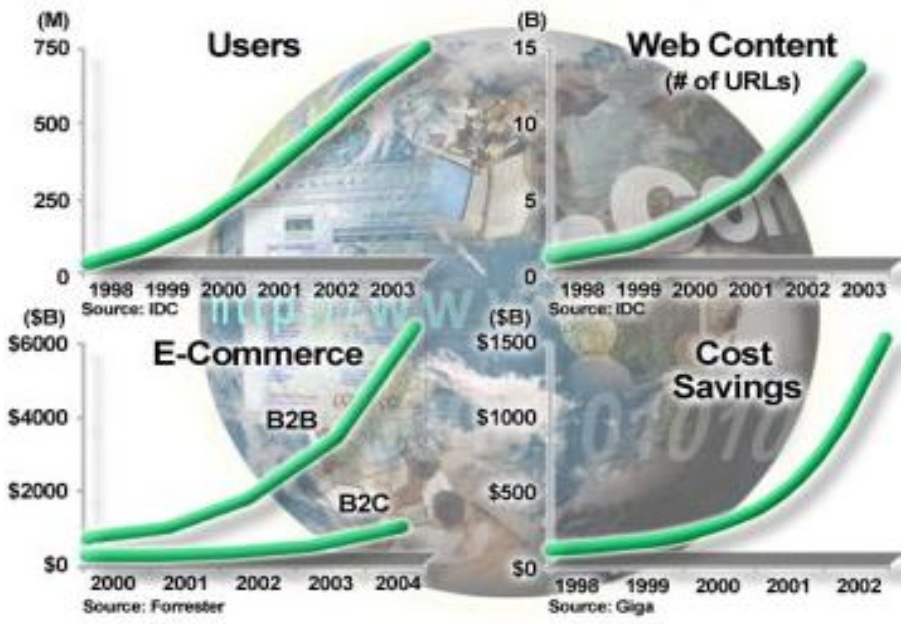
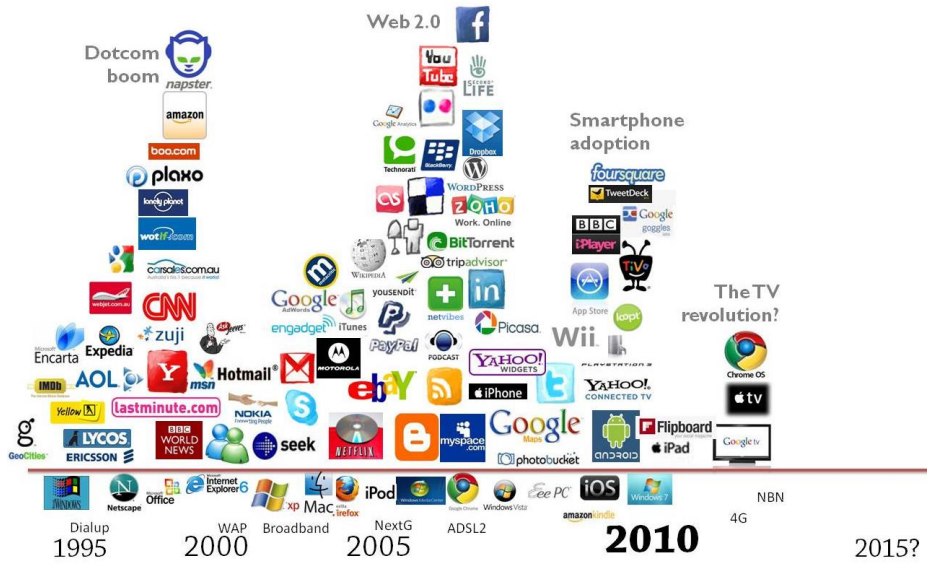
Changes by means of

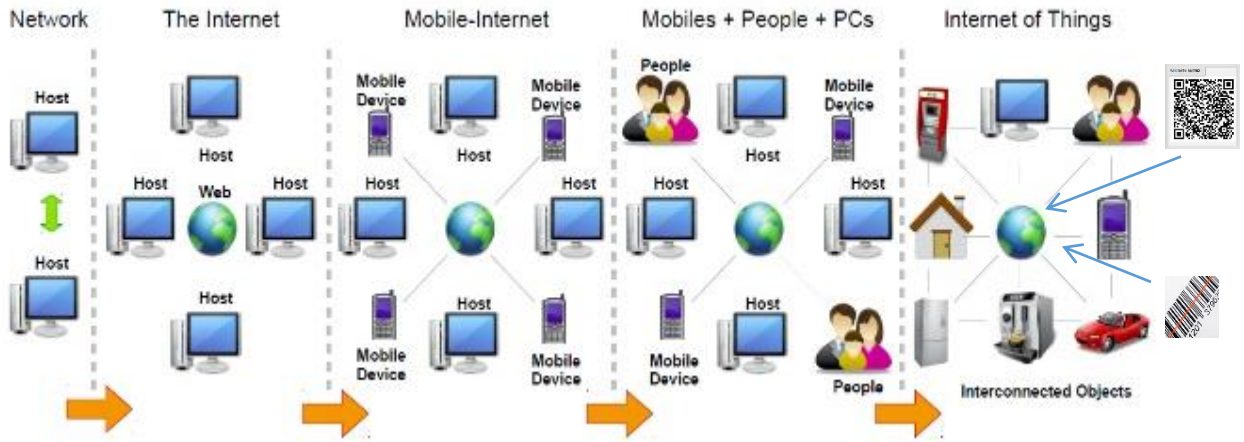
Two Revolutions

The internet Big Data Revolution

Strong Increase
USERS, WEB CONTENT, E-COMMERCE
COST SAVINGS





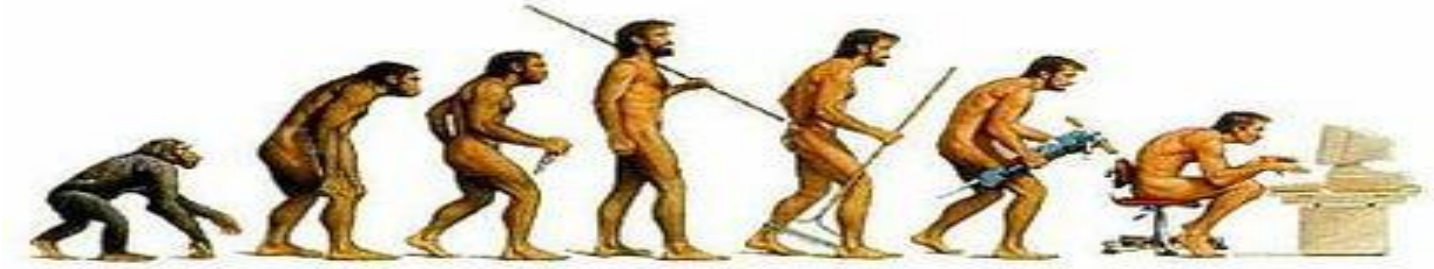


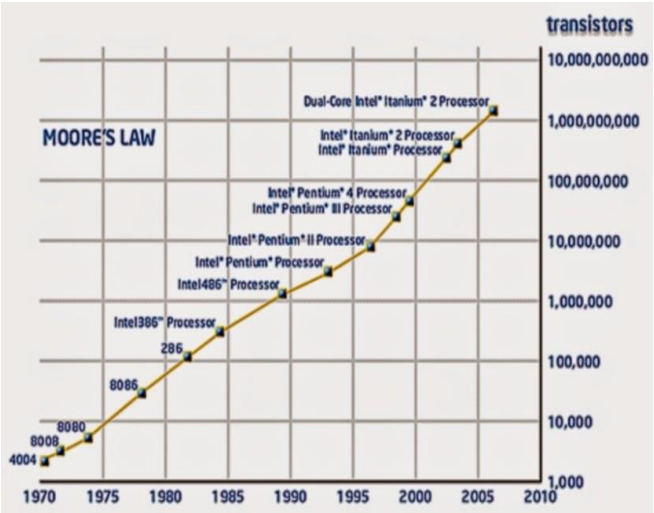
Internet of Things
From connecting Computer
To connect things

Statistics should promote a SEMANTIC WEB

that **provides standards** for **sharing data** and **reuse data** for different applications, for enterprises, for statistics purposes and scientific communities

The Computer and Technology Revolutions



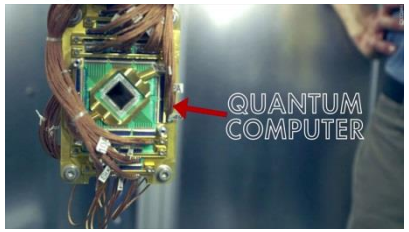


speed of the **computer** would double every 18 months and the costs would decrease by half every 2 years.

Parallel computing directly included in the new CPUs **increases** the possibility to **parallelize** modern **computer intensive** statistical **methodologies** that use independence such as resampling

Quantum computing with molecules that encode bits in **multiple states** . The QC naturally perform myriad operations in parallel, using only a single processing unit.

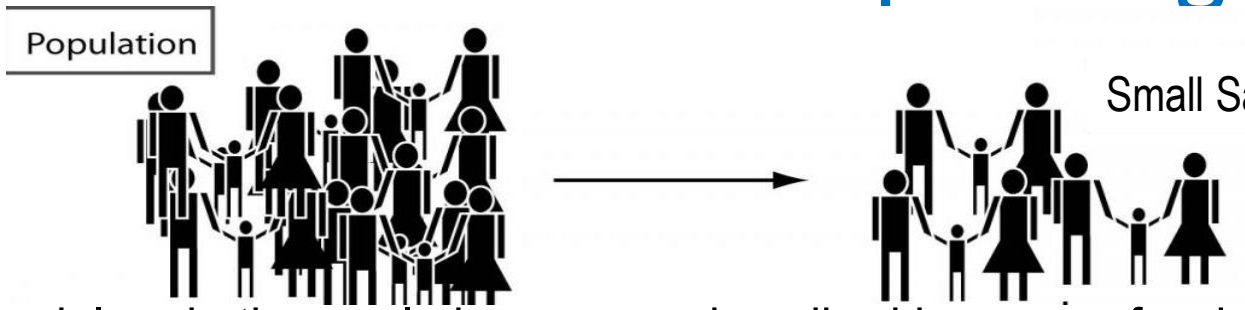
Quantum Computers and **parallel computing** very **helpful** for **computer intensive statistical methods** **(simulation resampling)**



STATISTICS BEFORE AND AFTER REVOLUTIONS

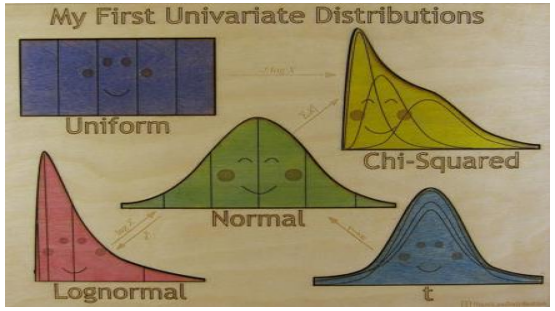
Small samples	vs	Large samples or Populations
Classical statistical Inference	vs	Computer-intensive statistical inference
Phenomena Univariate and bivariate	vs	Multivariate Phenomena in space and time domains

Statistics before computer age

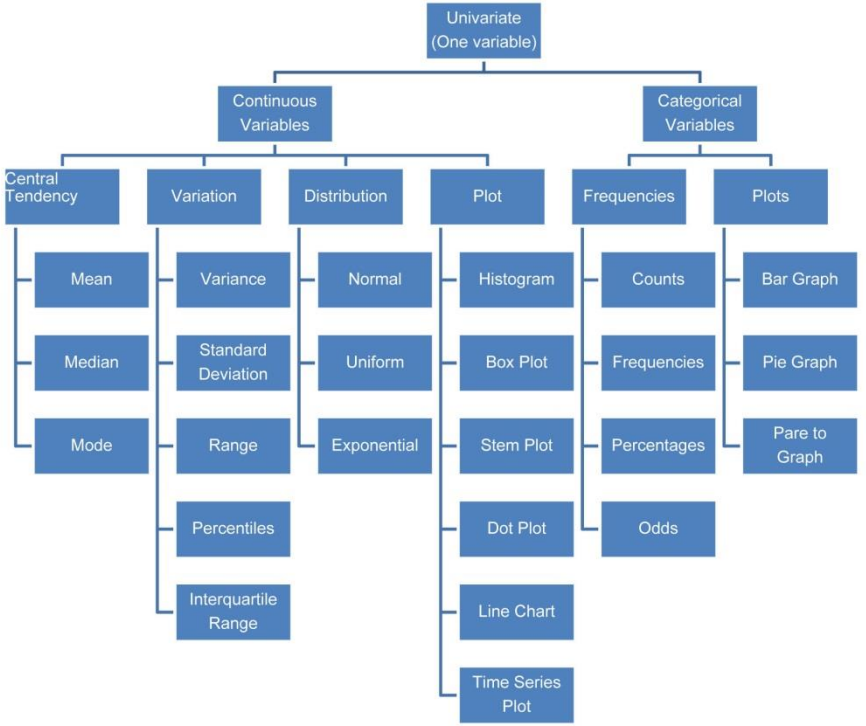


Manual data collection

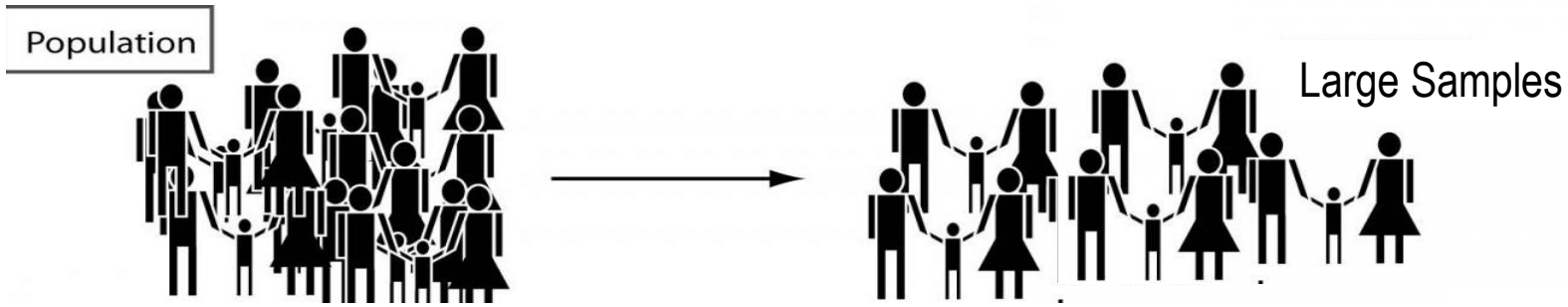
- Economic, social and other real phenomena described by one or few indicators
- Inference mainly on Univariate and Bivariate random variables
- Extensive use of parametric statistics
  especially under normality hypotheses



- Statistics based only on Mathematics and Probability



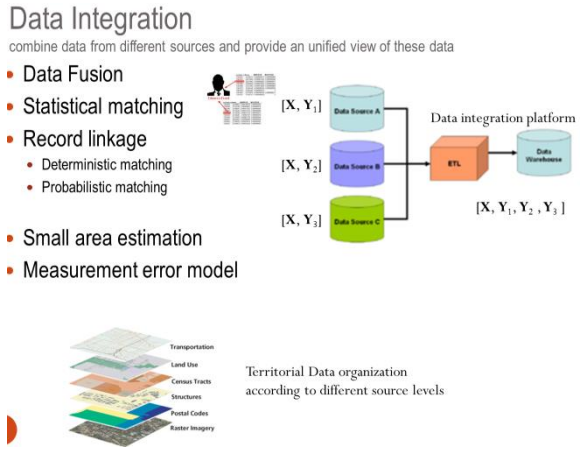
Statistics after computer-age



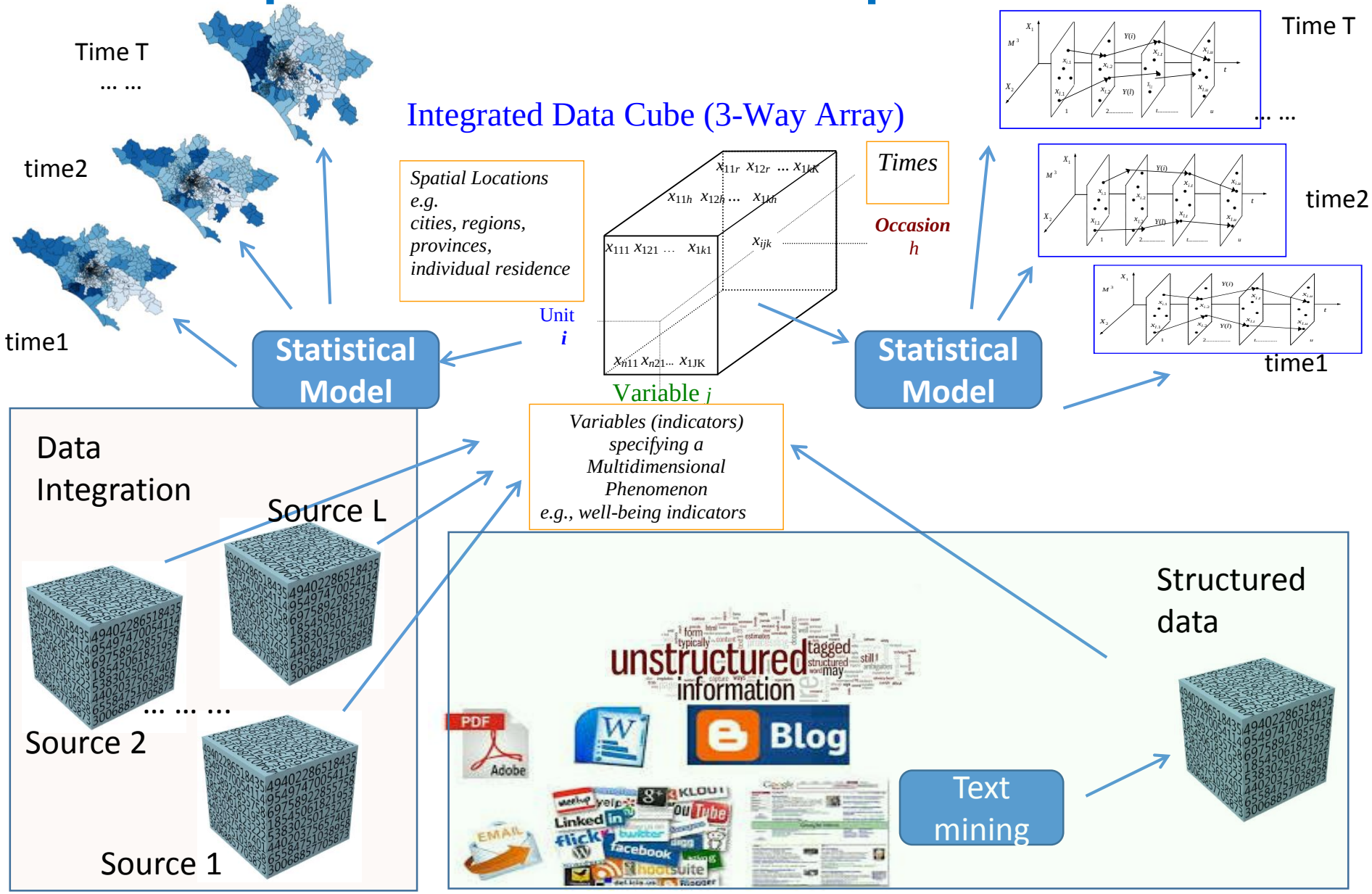
Electronic and Automatic data collection

- Statistics based on Mathematics, Probability and Computer Science (Computational Statistics)
- Computer-intensive statistical Inference (Jackknifing, Bootstrapping, Cross-validation, permutation tests)
- Economic, social and other real phenomena described in their full complexity

- BIG DATA: interconnect data



Big Data Complexity. How Big Data are formed? Multivariate phenomena with their space & time domains



Big Data: information + noise (error)

From data to information

Data Compression (reduce data of a given factor)

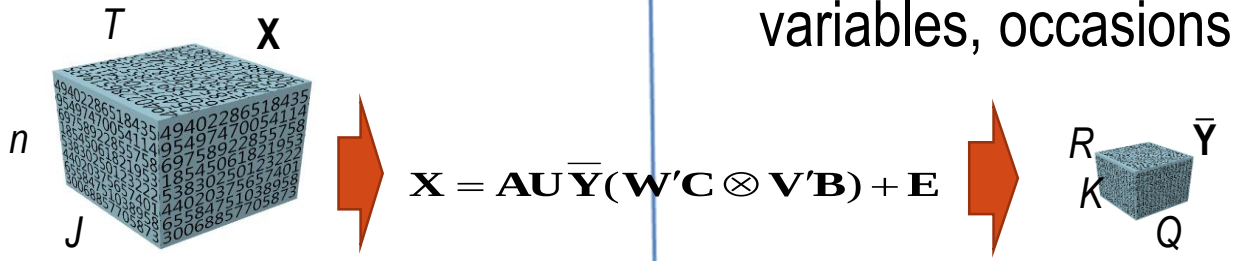
- Soft Data Compression (robustification)
- Data Fusion

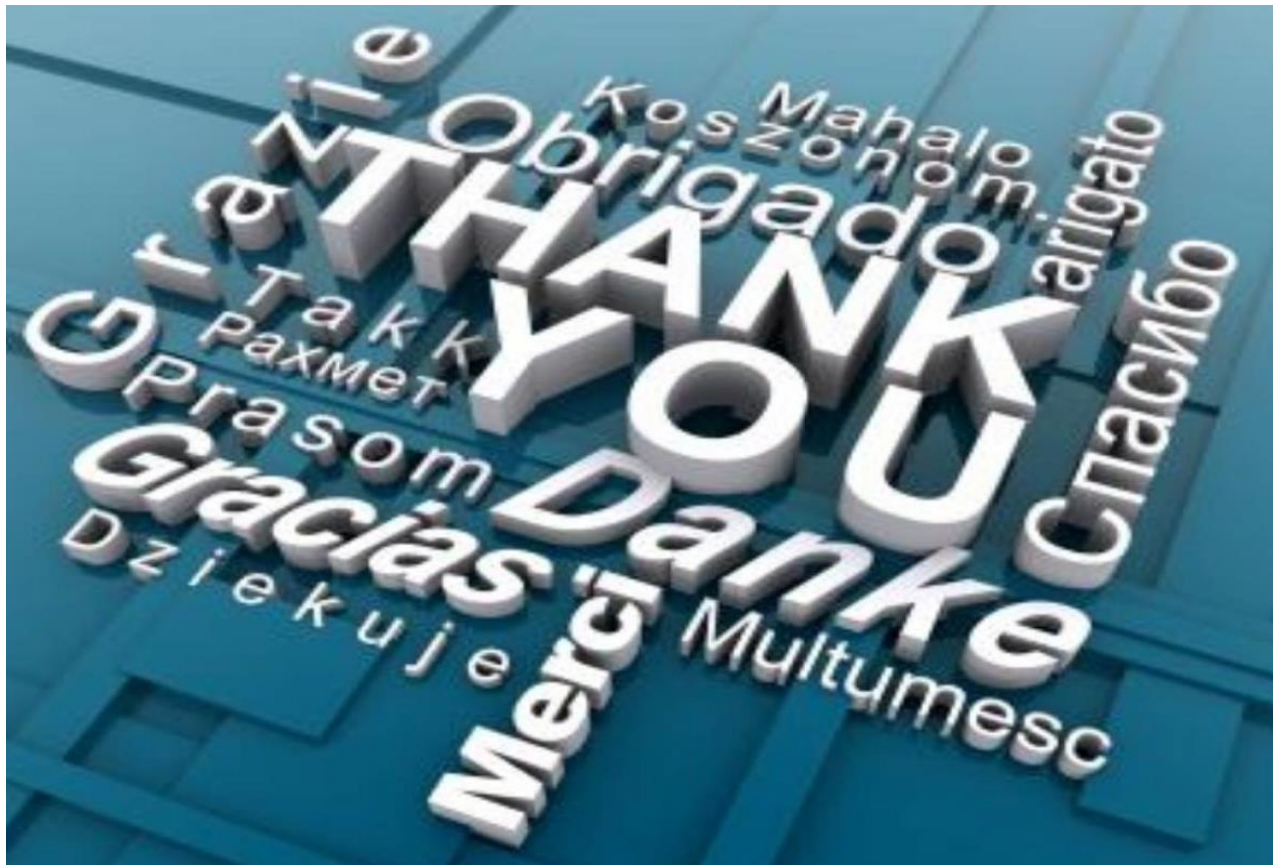
From information to knowledge

Statistical Modelling on compressed data

- Multivariate regression, VAR, SEM
- PCA, Factor Analysis, MCA, Composite Indicators
- Classification (Discriminant analysis, trees, SVM)
- Multidimensional scaling

- Hard Data Compression (Data mining)
- Taxonomy (science of classification)
- Clustering to identify typologies of objects, variables, occasions





L’attenzione è la forma più rara e più pura della generosità
Simone Weil

USERS OF STATISTICS

European Statistical Advisory Committee

☞ **ESAC has suggested a PORTAL for Communication**

PORTAL for USERS

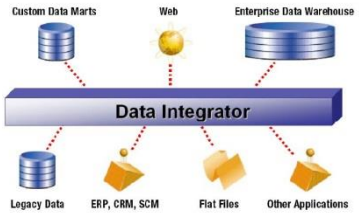
(a) Identify the very broad community of users of statistics;
(b) Segment the users' community into broadly homogeneous groups with similar interests

Groups of users Homogeneous for interest
CLUSTER ANALYSIS

Tools for decision making

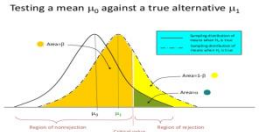
☞ Metadata;

☞ Data integrator



☞ Tools for Scenario Simulation (resampling for different scenarios)

☞ Tools to choose the best scenario (testing, cross-validation,…)



COMPUTER-AGE STATISTICAL INFERENCE

Resampling: Computing random sampling with replacement

Jackknifing: Estimating the precision of the sample **statistics** by using the observed data

Bootstrapping: Estimating the (*empirical*) *sample distribution* of the *statistics*.

Robust alternative to inference based on parametric assumptions when these are in doubt;

Utilization: **compute standard errors**, **confidence interval**, and also for **testing**;

Cross-validation: method for validating a predictive model. The goal is to estimate the expected level of fit of a model to a data set that is independent of the data that were used to train the model.

Divide the sample in validation and training sets

- Exhaustive cross-validation
  - Leave-p-out cross-validation
  - Leave-one-out cross-validation
- Non-exhaustive cross-validation
  - k-fold cross-validation
  - 2-fold cross-validation

Utilization: **compare** performances of different predictive models

variable selection.

Permutation test (exact test):

MCMC methods