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Matching in the Australian Census Post-Enumeration Survey

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with thanks to Tenniel Guiver (ABS)

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What we will cover

- Overview of PES matching
- Computer-assisted matching PES 2006
- Automated data-linking
- Application to PES 2011

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Overview of Census operations

- Census collector assigned an area
- Dwellings recorded in collector record book
  - leaves form with household
- Respondents fill out their own form
  - most on paper, some on-line
- Collector picks up form
  - or establishes that on-line form was filled in

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Overview of PES operations

- PES provides a **probability sample**
  - of private dwellings
  - of persons resident in those dwellings
- **Matching** to Census takes two steps
  - find the dwelling
  - find the person **wherever** they were counted
- Up to 2001 process mainly clerical
- In 2006 computer-assisted
- In 2011 use automated data-linking
  - refer uncertain cases to clerical staff

Information collected by PES

- **Blocklist** of dwellings found in PES
- For each **person** in selected dwellings:
  - **Personal details**
    - name, sex, age, date of birth, marital status, country of birth
  - **Census night address**
    - may not be the current address
  - **Search addresses**: places where the person **could** have been put on a Census form

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Information from Census

- **Collector's Record Book**
  - lists all the dwellings found and whether:
    - occupied (and provided a form)
    - unoccupied
    - non-contact - occupied but no form provided
- **Personal details**
  - for persons in the dwelling **on Census night**
  - including usual residence address
- Limited personal details for persons usually resident but **temporarily absent**

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Dwelling matching

- Search the collector record book
  - all information stored on computer
  - as images "**snippets**"
  - confirm address on Census form if available
  - computer may provide multiple CRBs
- If no match, view Census forms
  - check addresses
  - perhaps names of residents
- Can view map
- Can check CRBs of surrounding areas
- Can view PES blocklist

Dwelling match issues

- Two dwellings match to one
  - on PES or on Census
- Search address too unclear
  - e.g. "in Sydney"
  - in which case we impute the probability of a match (from similar search addresses)

Person matching

- For each PES person
  - Check the dwelling for similar person
  - Check persons "temporarily absent"
  - Record **field match codes**
    - eg. for each of name, sex, age, ...
    - eg. "name" has six codes
  - Computer assigns **person match code**
  - Computer may ask clerk to check **household and family** structure
    - easy for clerk, hard for computer

Quality checking

- In 2006, every dwelling **processed twice**
  - two different clerks
- If different results, send to expert clerk
  - to make the final decision

Indigenous communities

- **More difficult** because
  - addresses often incomplete or vague
  - mobile population
  - names change e.g. for religions reasons
- Use **different rules** for matching
  - e.g. less penalty for failing to match on name
- Use **paper listings** of community members in a variety of sort orders

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Automatic matching for 2011

- Uses **probabilistic linking**
- Can match PES person at **any** address
  - not just specified search addresses
- Gives list of linked persons from Census
  - either "links" or "possible links"
  - any possible links are **reviewed clerically**
- All confirmed links are treated as matches
- Any person **not linked** after this goes to the **clerical matching** process

What is Probabilistic Data Linking?

File A

File B

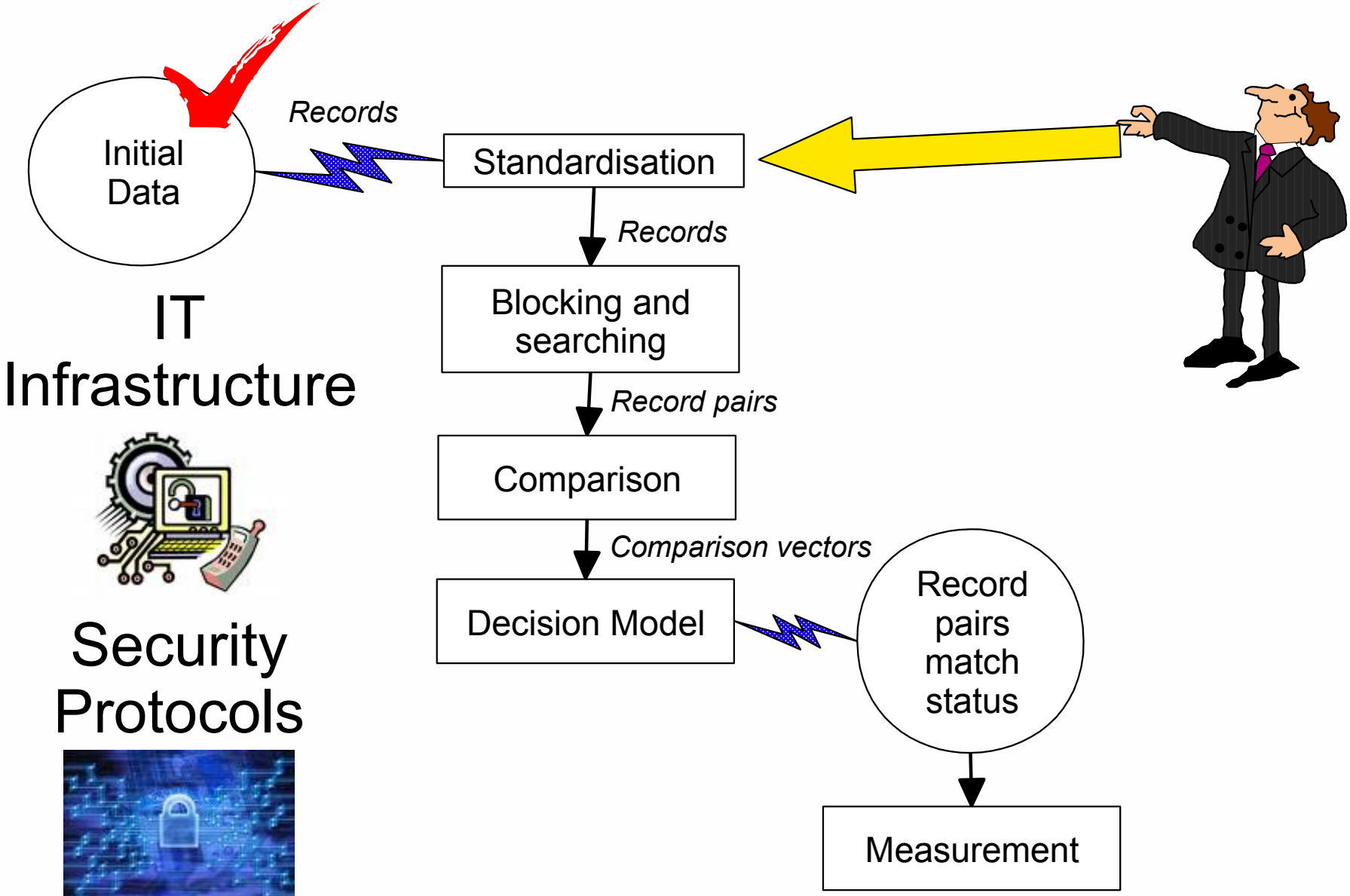
Output

Person 1 file A data file B data

Person 2 file A data file B data

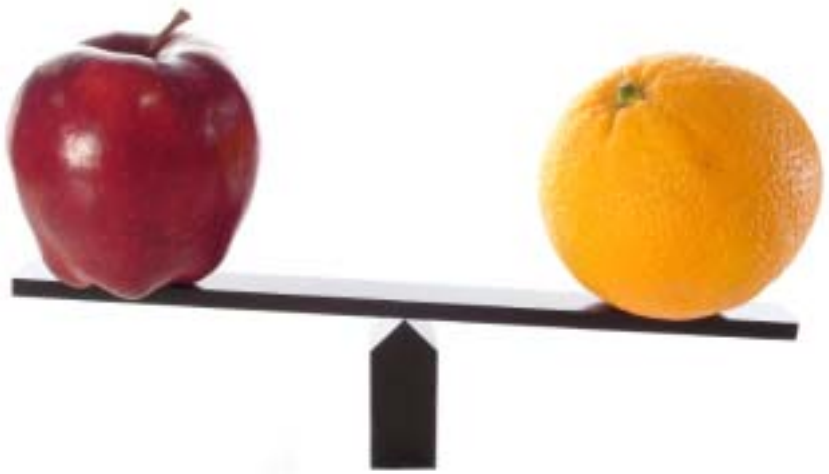
...

The Data Linking Process



Standardisation

- This initial stage ensures that the data on the two files is consistently recorded
- For example sex may be recorded as M or F on one file and Male and Female on the other



Standardisation

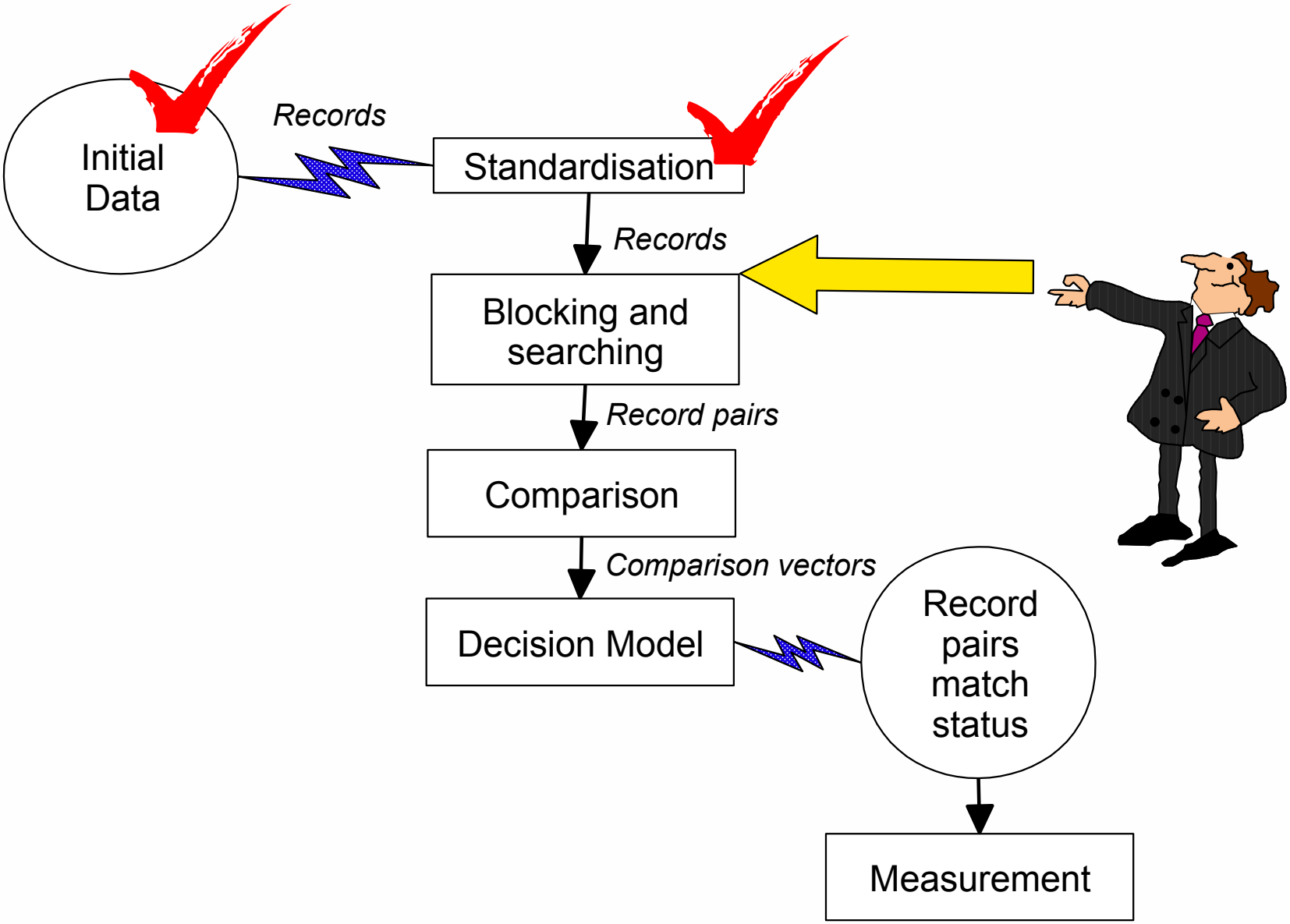
- Names
  - name repair
  - nicknames and variants
- Addresses
  - parsing
  - coding (e.g. meshblocks)
- Dates

Hevin → Kevin

Kathy
Katherine
Kathie
Kath

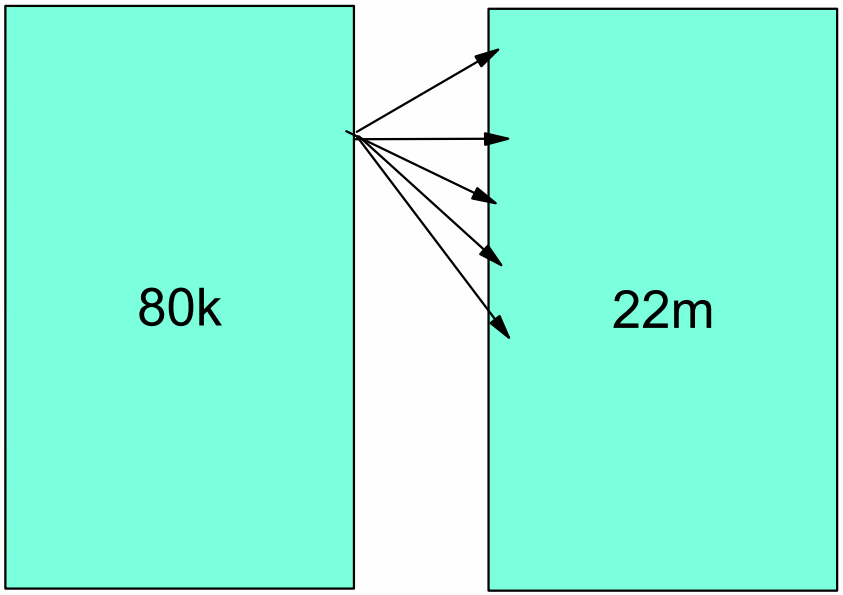
1	Dunrossil	Drive	YARRALUMLA	ACT	2600

The Data Linking Process



Blocking

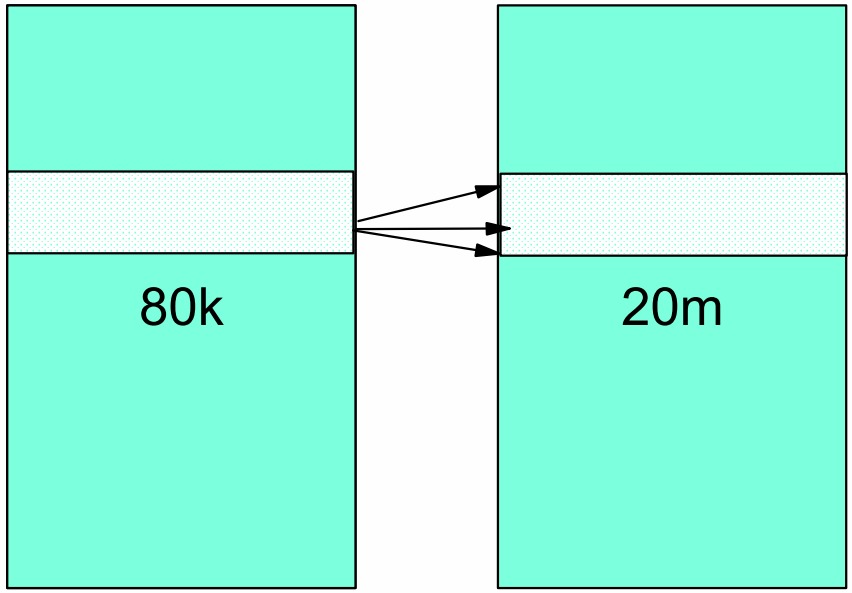
No Blocking



2×10^{12} comparisons

Blocking

e.g. sex, cob, state, CD

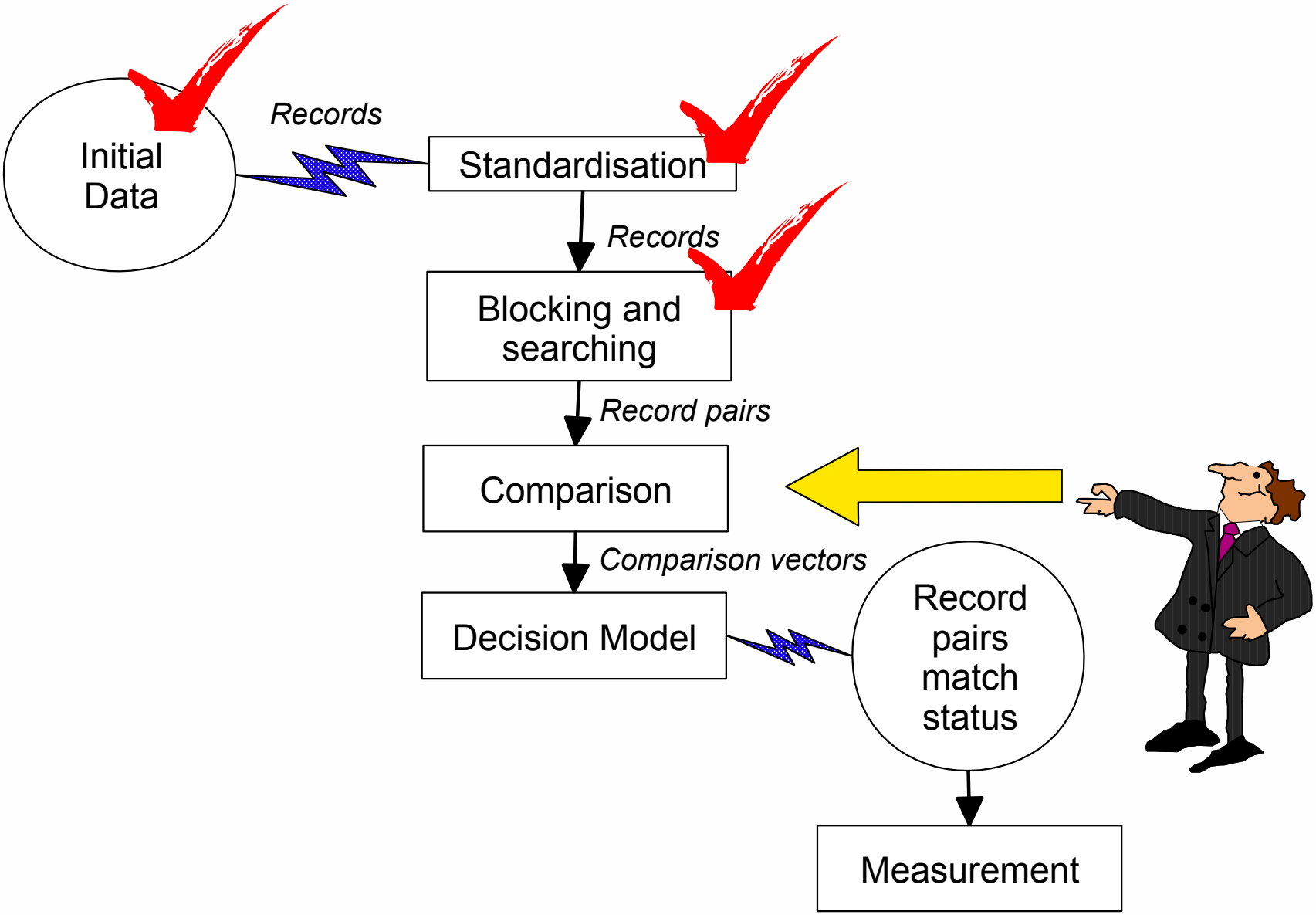


If, say 1000 blocks 80 and 20,000 each

2×10^{9} comparisons

Blocking variables must be very reliable as no records outside the block are compared

The Data Linking Process



Variables

2006

Melanie Brown
Female, 16/11/85
1 ABC St, Inner Suburb, Vic 3010
share house 2F, 1M
university student, single
highest schooling Yr 12
highest qual: still studying
no live births
born in Australia
parents born in England
5yrs ago lived:
11 Eve St, Midland, 3091
ancestry English
speaks English

2011

Melanie Searle
Female, 16/11/85
6 DEF Rd, Outer Suburb, Vic 3215
couple 1M, 1F
pharmacist, married
highest schooling Yr 12
highest qual: bachelor degree
no live births
born in Australia
parents born in England
5yrs ago lived:
1 ABC St, Inner Suburb, Vic 3010
ancestry English
speaks English

Improving the Distinguishing Power of Names

Name	Sex	Common Male Name	Uncommon Male Name	Common Female Name	Uncommon Female Name
Jonathon	M	John	------	-----	-----
Tenniel	M	------	Tenniel	------	------
Jenny	F	-----	-----	Jennifer	-----
Tenille	F	-----	-----	------	Tenille

Other Variables

- Surnames
  - Common/Uncommon
- Country of Birth
  - set to missing if born in Australian
  - otherwise use 2 digit region of birth
- Indigenous
  - more likely than an unmatched pair agrees on being non-indigenous

Comparisons

- When comparing a record from file A with one from file B, we look at the same fields on each

	dob	MB	cob
record a	16/3/79	1031812	Australia
record b	16/3/79	1390101	Australia
comparison	1	0	1

- Combine the results of field comparisons to create the final, record pair comparison value.
  - The bigger this is the stronger the chance of a match
- Underlying mathematical theory in this step.

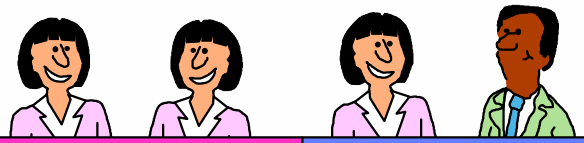
Field Comparison Functions

- SHACKELFORD SHACKELFOBD (0.96)
- SHACKLEFORD SMACKLEFORD (0.95)
- ITMAN SMITH (0.57)

- Similarly, we can use partial agreement on numeric fields

Probabilities and Weights

- Inputs
  - probability that the fields agree given that the records belong to the same person
  - probability that the fields agree given that the records belong to different people



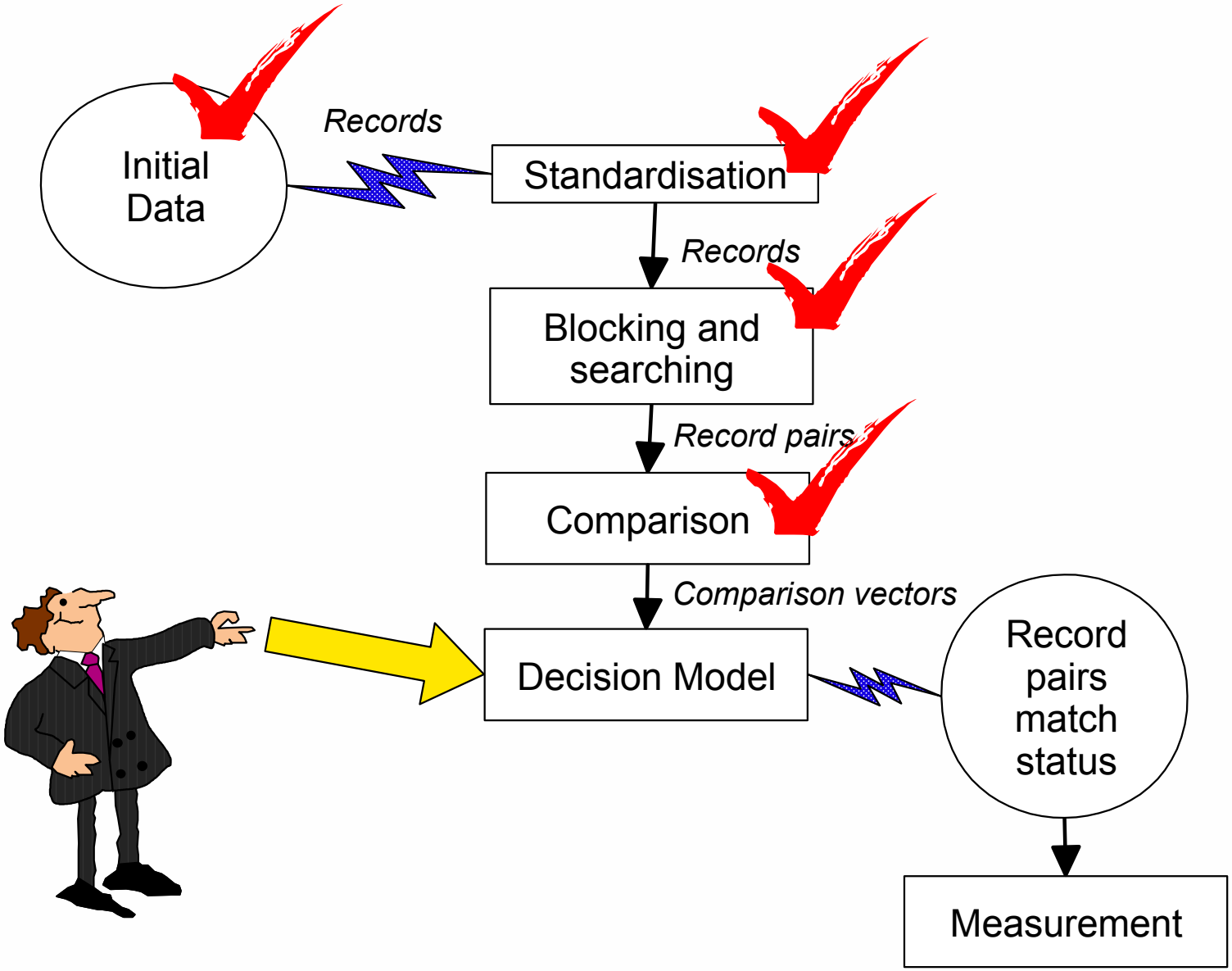
	same person	*different*	agree weight	disagree weight
sex	0.999	0.5	0.3	-2.7
date of birth	0.95	0.0015	2.8	-1.3

- Different variables have different distinguishing power

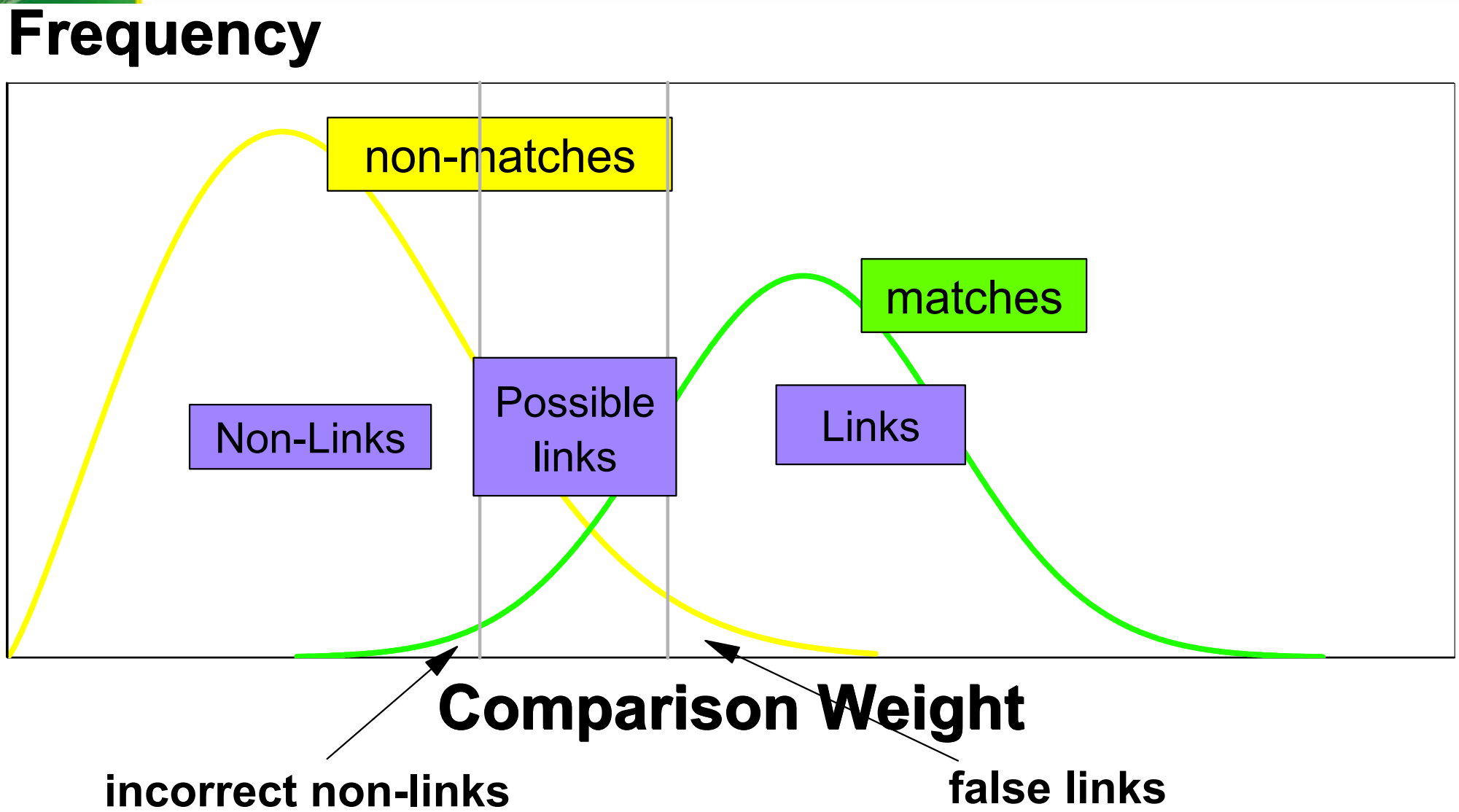
What Have We Got So Far?

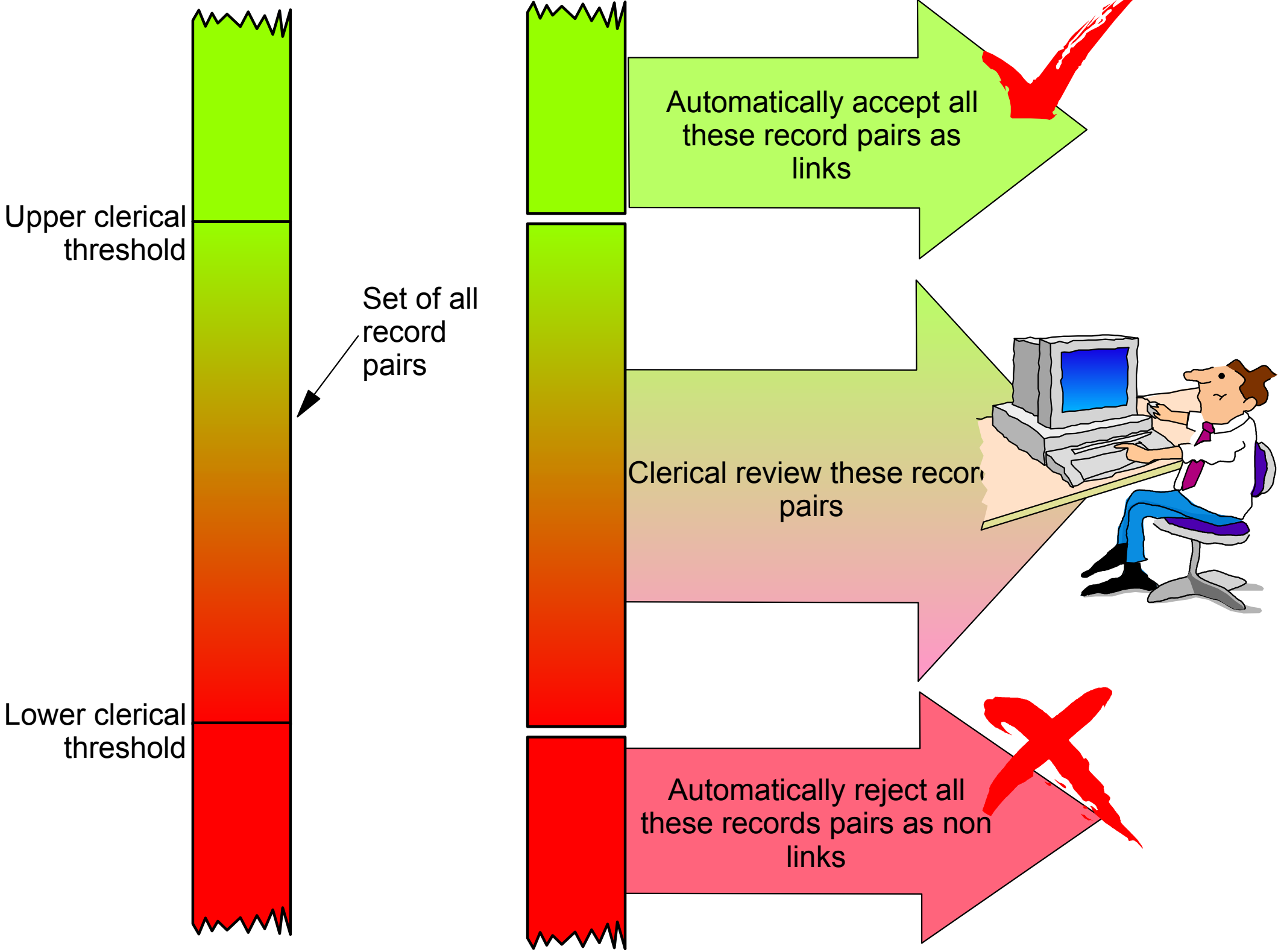
- Set of matched records with an associated comparison weight
- Lots of these, high weights, low weights and in-between
- Many to many comparisons

The Data Linking Process

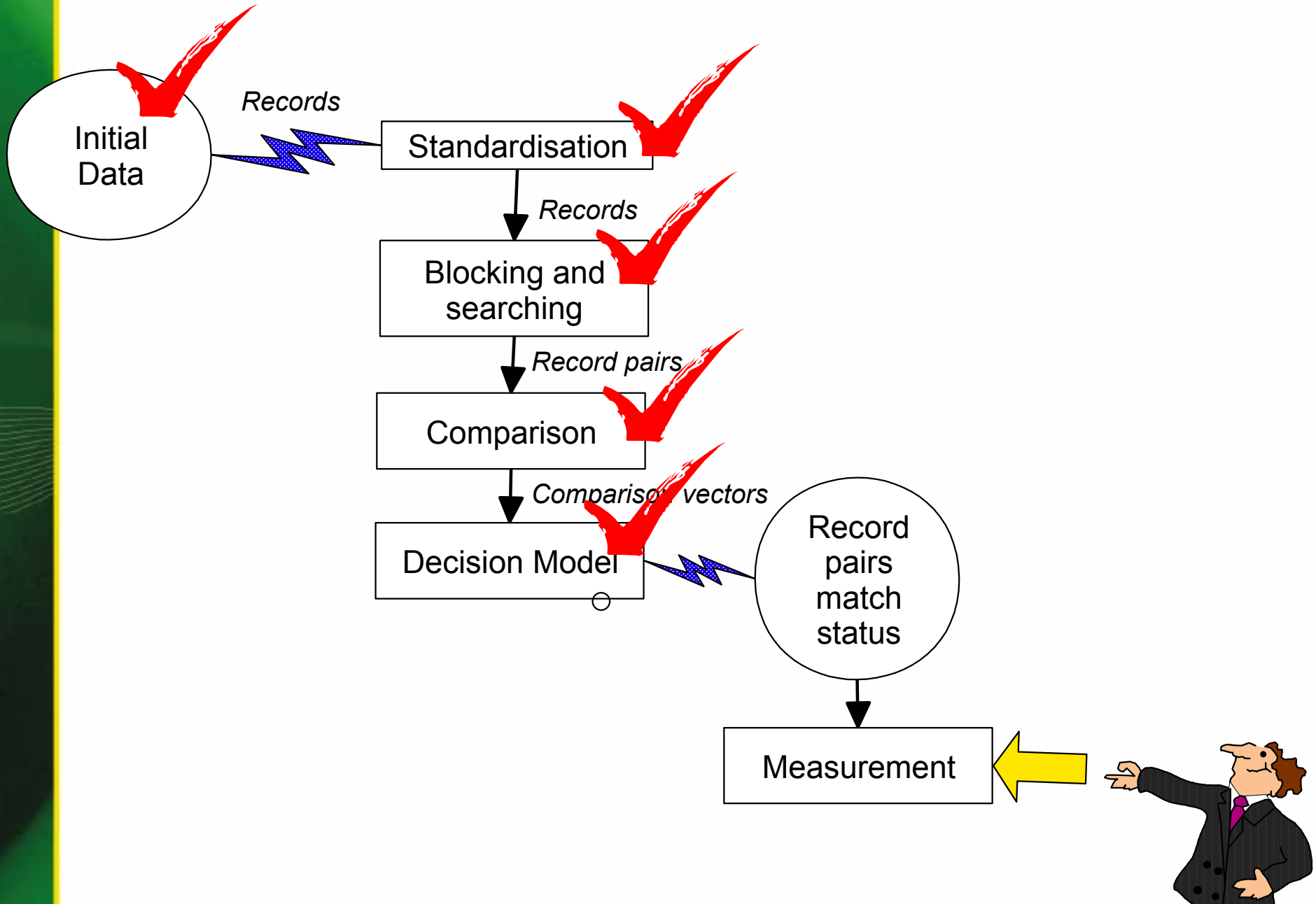


Results of Comparisons

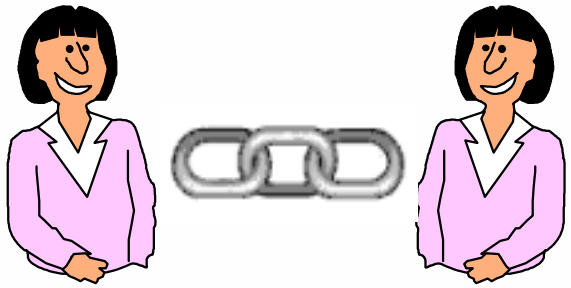
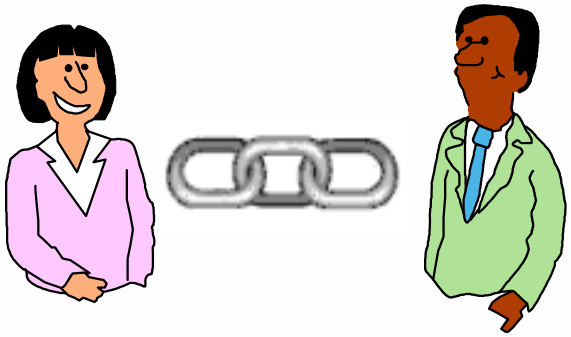
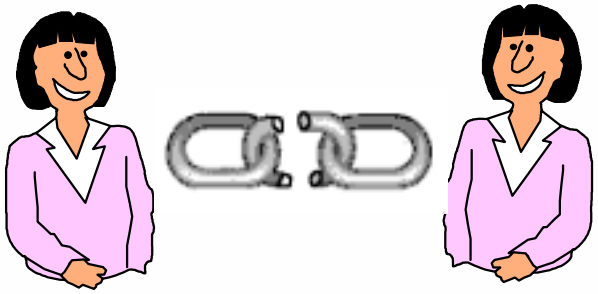
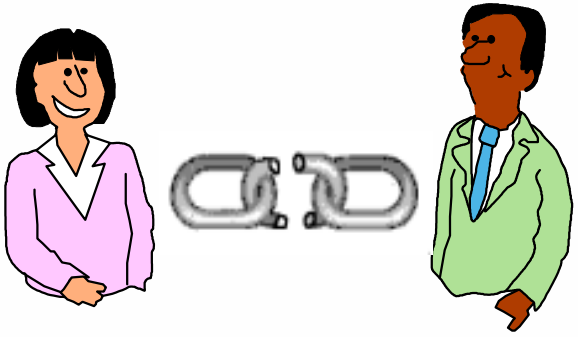



Upper clerical threshold
Lower clerical threshold
Set of all record pairs
Automatically accept all these record pairs as links
Clerical review these recor pairs
Automatically reject all these records pairs as non links

The Home Stretch



Characterising the Results

	Matches	Non-matches
Links		
Non-links		

PES Quality Study

- A study to investigate the feasibility of using data linking to automate the clerical matching process
- Found to introduce efficiencies **and** find extra matches

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Benefits of automated match

- Works with vague search addresses
- Finds additional matches
  - when tested on PES 2006
- Better use of clerical resources
  - used on the difficult cases
  - and to confirm the questionable cases
- Can ensure **high match accuracy**
  - only link when match is clear
    - e.g. aim for ~60,000 automated links
    - **clerically review** the remaining ~30,000 (to find ~20,000 extra matches).

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The Future: PES 2011

- Aim to **integrate** automated data linking into the PES clerical process
- **Batch** operation
  - one state at a time as processing completed
  - supplement with a final nationwide search.
- **System design** underway

Linking software: FEBRL

- ABS used free software FEBRL
  - author Peter Christen (ANU)
  - does blocking, linking etc.
  - written in PERL
  - **slow**
- Huge datasets
  - 80,000 PES persons, 20,000,000 Census
  - speed depends on platform
  - need lots of RAM memory

ABS changes to FEBRL

- New **comparators**
  - e.g. how close are two ages
    1 year age difference is a good match
  - special treatment of "missing"
- **Speed up** indexing
  - so can quickly access data for a record
- Add **clerical review**
  - displays relevant data for two records
  - allows clerk to enter "match" or "no match"
- All done with older version of FEBRL