Environmental Sensing

Ilist - Indexed List

Concepts and principles

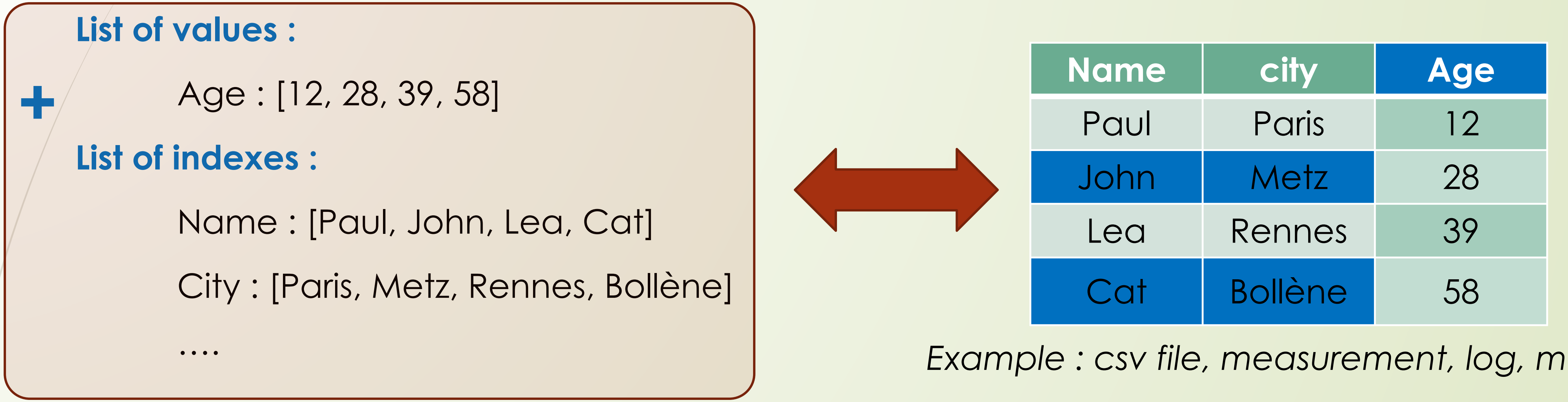
0 – Main

- **Indexed list**
    - 0 - Presentation
- **Objectives**
    - Structure optimization
        - 1 - Structure understanding
        - 2 - Structure optimization
        - 3 - Size optimization
    - Integrate process
        - 4 - Building process
        - 4 - Interface tools

- **Associated tools**
    - 5 - Data format
    - 5 - Exchange format
- **Extension**
    - 6 - Environmental sensing
    - 6 - Sensor acquisition

0 - Tabular data

Structure



List of values :

+ Age : [12, 28, 39, 58]

List of indexes :

Name : [Paul, John, Lea, Cat]

City : [Paris, Metz, Rennes, Bollène]

….

Name	city	Age
Paul	Paris	12
John	Metz	28
Lea	Rennes	39
Cat	Bollène	58

Example : csv file, measurement, log, matrix

Why Ilist ?

- The majority of work processes are underpinned by Sheets
- The main Open-data format is CSV
- Existing tools process data but not data structures

Such tool doesn't exist !

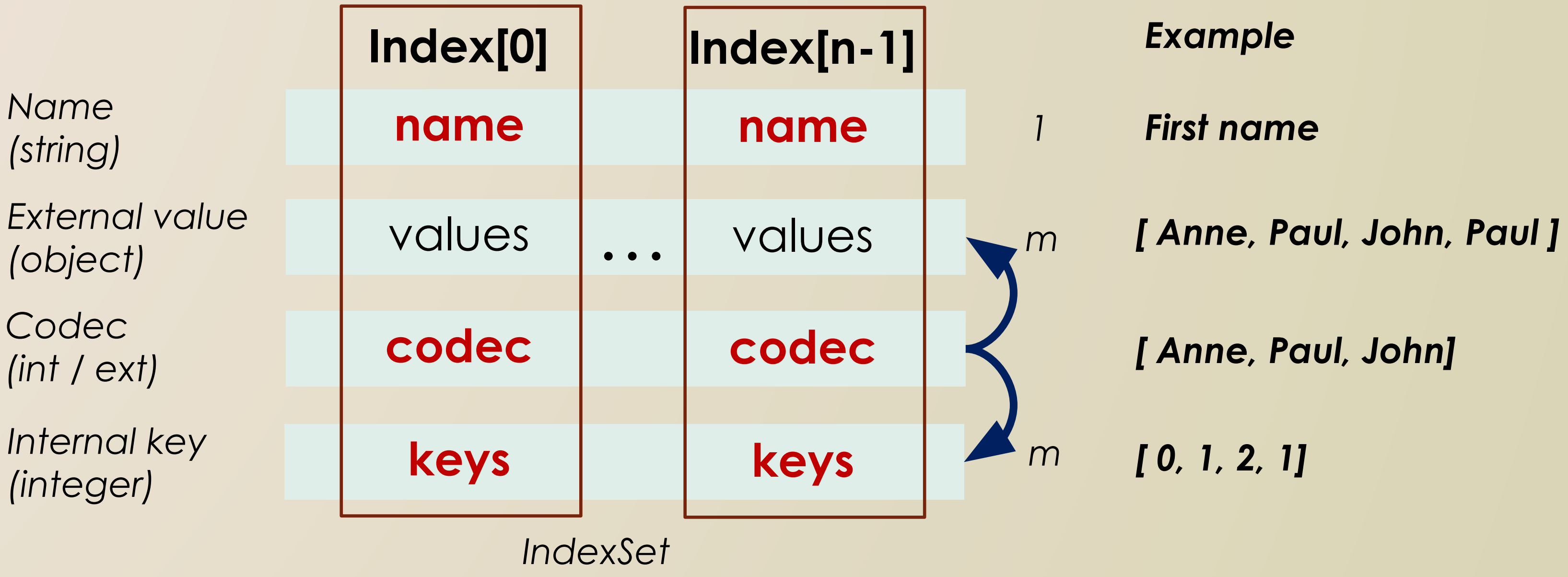
0 – Ilist structure

Red : static value
Black : dynamic value

n : number of indexes
m : number of values

Two levels

- **External values**
  (every kind of object)
- **Internal keys**
  (integer)



	Index[0]		Index[n-1]		*Example*
Name (string)	name		name	*1*	***First name***
External value (object)	values	. . .	values	*m*	***[Anne, Paul, John, Paul]***
Codec (int / ext)	codec		codec		***[Anne, Paul, John]***
Internal key (integer)	keys		keys	*m*	***[0, 1, 2, 1]***

IndexSet

Example

indexes

name	score	name	age	subject
values	10	Paul	16	math
	12	Lea	15	math
	15	Lea	15	english

External

codec ⟷

keys

Structure analysis

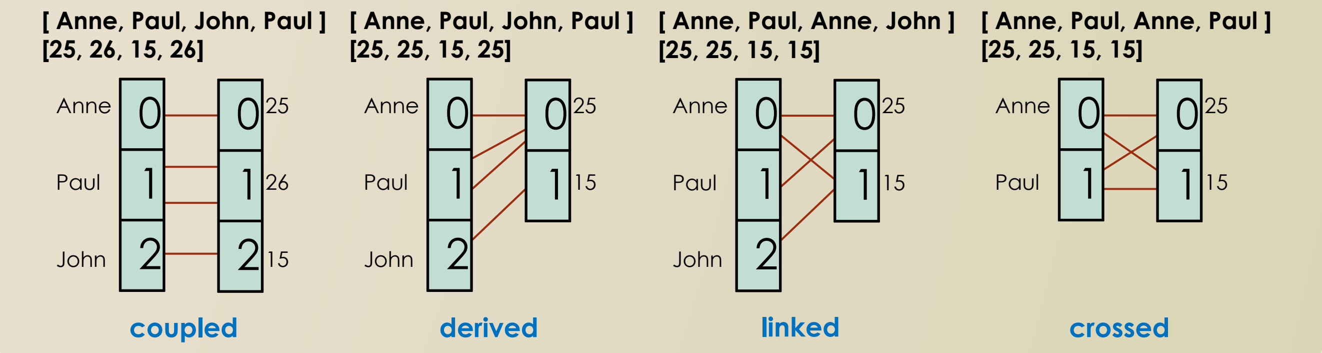
score	name	age	subject
0	0	0	0
1	1	1	0
2	1	1	1

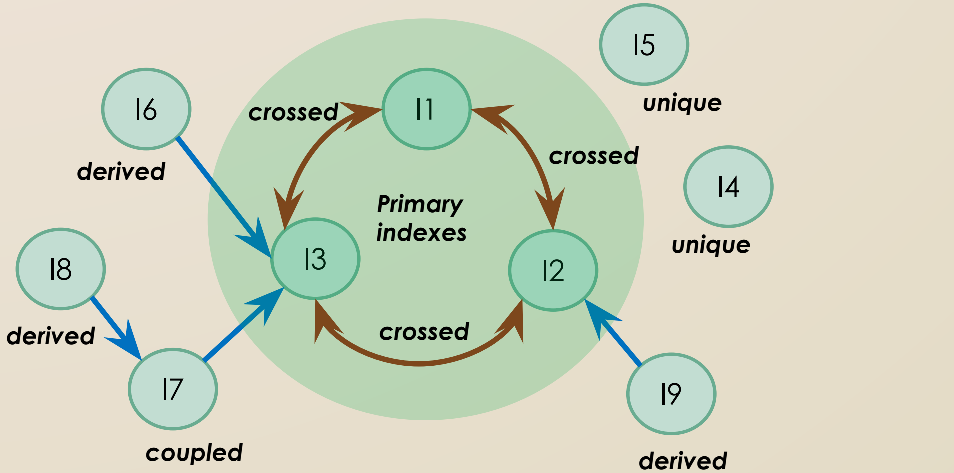
Internal

1 – Structure understanding

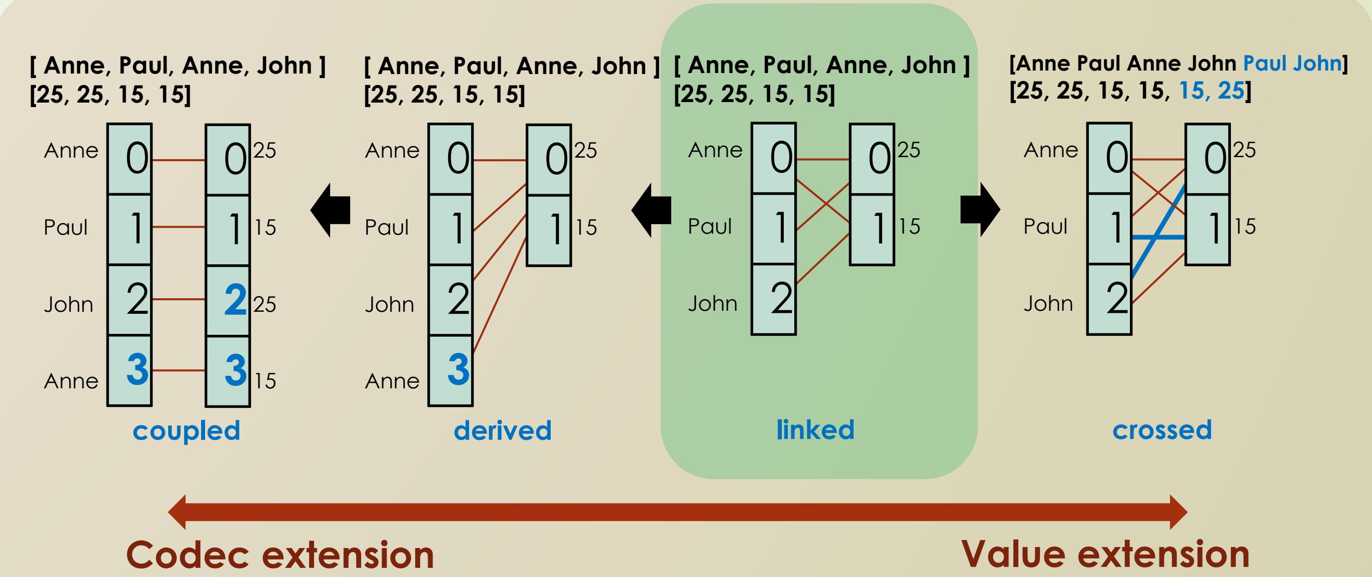
- **Relationship analysis**
  - Index qualification
  - Index relationship
- **Data structuration**
  - Canonical format
  - Convergence

Index relationship



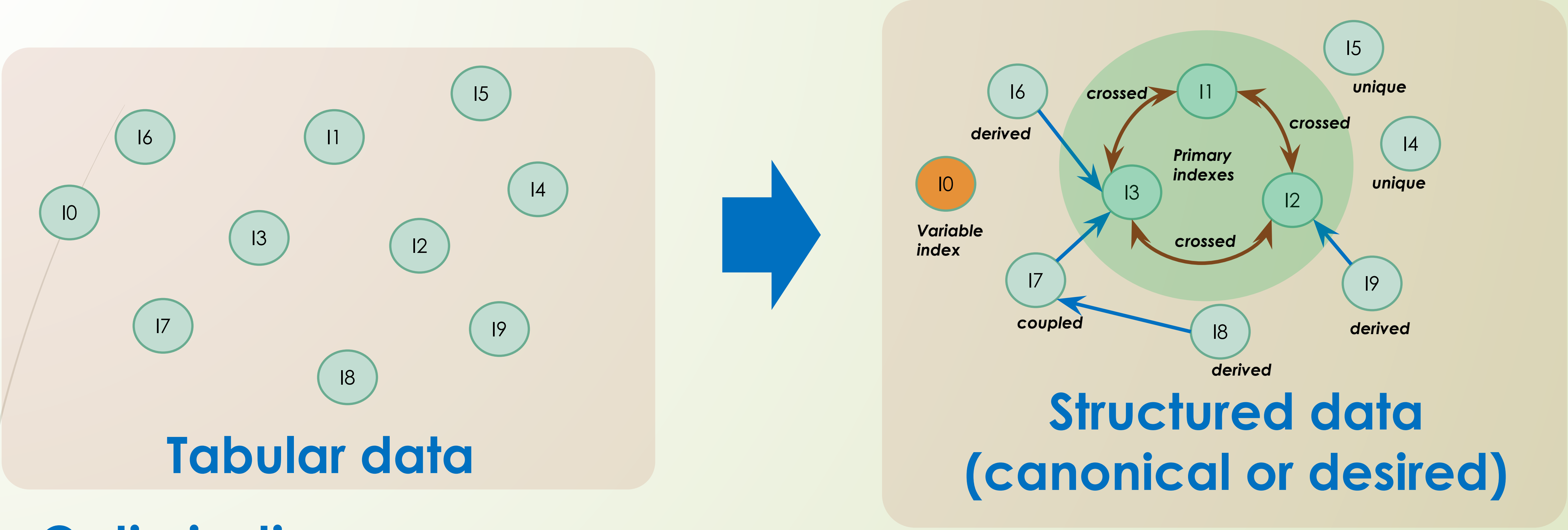


Canonical structure



Convergence

2 – Structure optimization



Tabular data

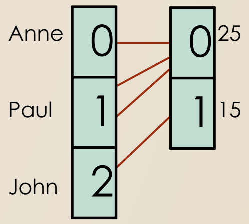
Structured data (canonical or desired)

- **Optimization**
  - minimization of additional data to achieve canonical structure
- **Consistency**
  - enforce compliance with the conceptual data model (e.g. cardinality)
  - identification of additional data to achieve the desired structure

3 – Size optimization

- **Canonical structure**
  - Minimal structure
- **Minimal size**
  - No multiple value
  - Keys optimization
- **Exchange format**
  - Text : JSON format
  - Binary : CBOR (RFC 8949)

[Anne, Paul, John, Paul]
[25, 25, 15, 25]



derived

CSV format

[Anne Paul John Paul]

[25, 25, 15, 25]

Default format

[Anne Paul John]
[0, 1, 2, 1]

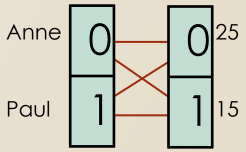
[25, 25, 15, 25]
[0, 0, 1, 0]

Optimized format

[Anne Paul John]
[0, 1, 2, 1]

[25, 25, 15, 25]
[0, 0, 1] *(relative keys to parent keys)*

[Anne, Paul, Anne, Paul]
[25, 25, 15, 15]



crossed

CSV format

[Anne Anne Paul Paul]

[25, 15, 25, 15]

Default format

[Anne Pau]
[0, 0, 1, 1]

[25, 15]
[0, 1, 0, 1]

Optimized format

[Anne Pau] *(implicit keys)*

[25, 15] *(implicit keys)*

Example : Open-data - french charging point (EVSE)

7.5 Mo – 11 000 rows – 49 columns

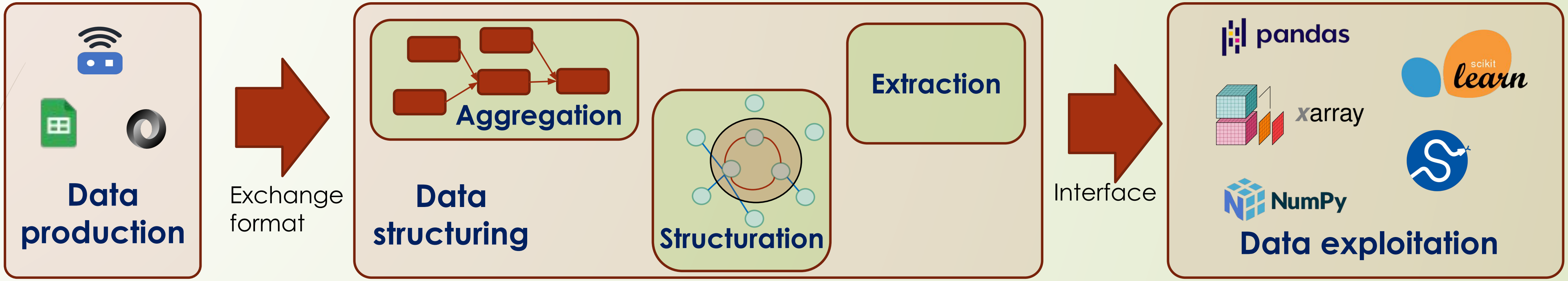
Analysis :

Indexes : 1 coupled, 6 derived, 1 crossed, 41 linked
Canonical format : 1 crossed, 48 derived

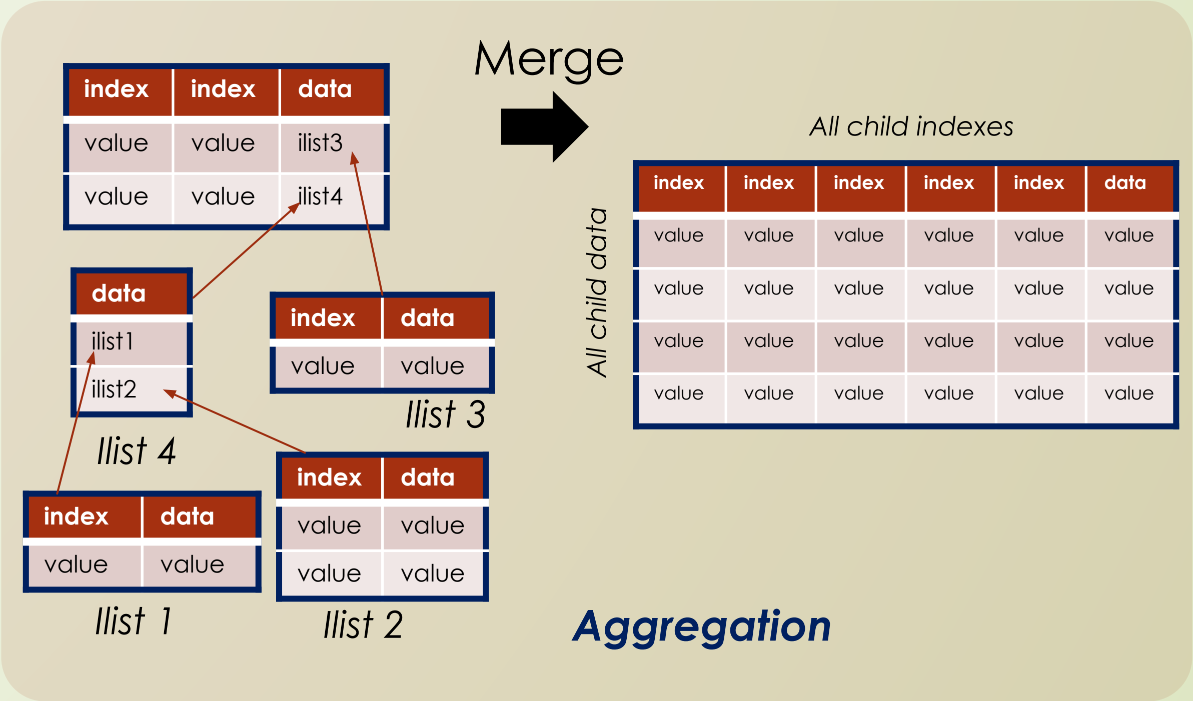
File size :

Default :	3.7 Mo
Optimized :	2.5 Mo
CBOR optimized :	**1.7 Mo (gain : 77% !)**

4 – Integrate process



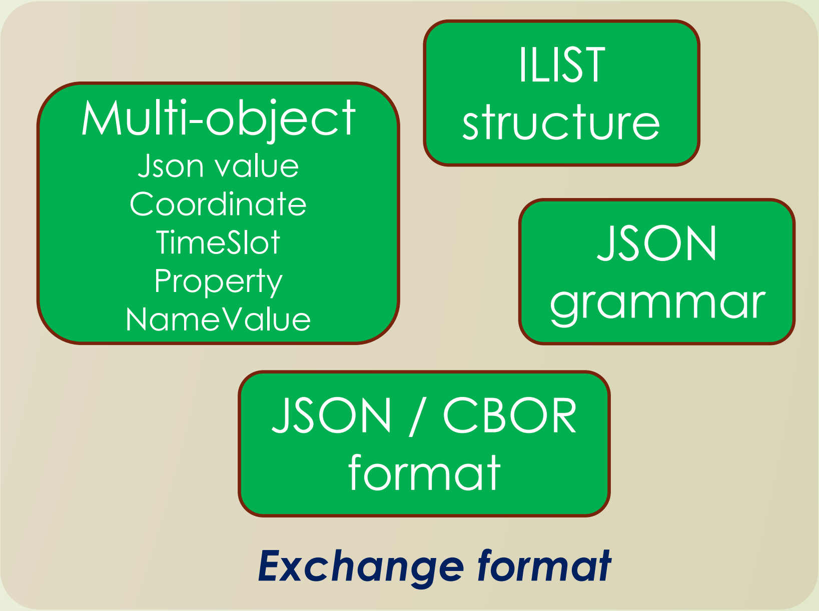
- **Data production interface**
  - Exchange format (Json, Bluetooth, CSV)
- **Aggregation / merge functions**
  - Adapted to projects / organizations
  - Add information without altering
- **Export to analysis tools**
  - Canonical structure compatibility



5 – Data format

- **Large set of objects**
  - New format (timeslot, property)

- **JSON representation**
  - Exchange format



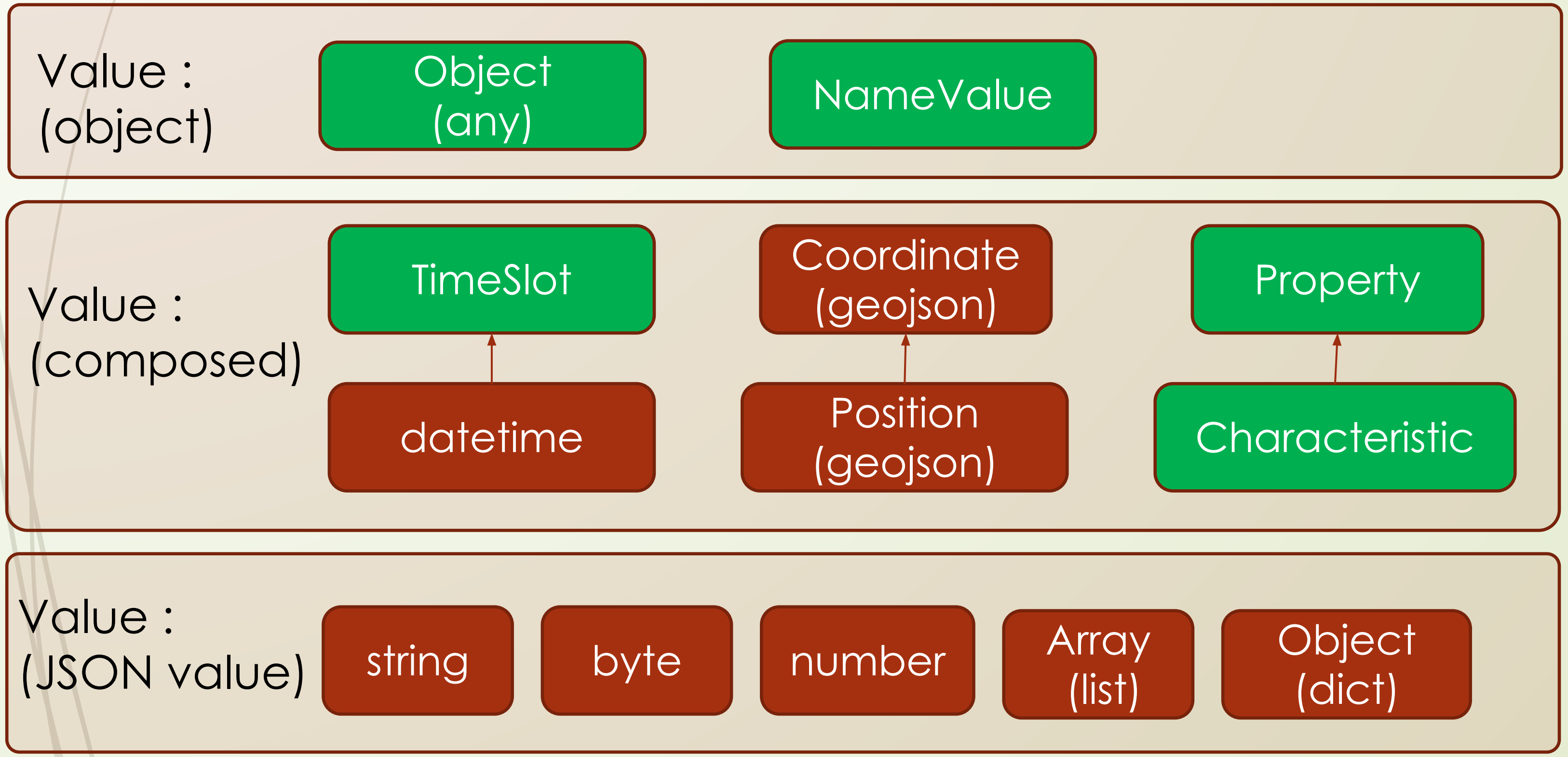
Multi-object
Json value
Coordinate
TimeSlot
Property
NameValue

ILIST structure

JSON grammar

JSON / CBOR format

Exchange format



Value : (object)
Object (any)
NameValue

Value : (composed)
TimeSlot
datetime
Coordinate (geojson)
Position (geojson)
Property
Characteristic

Value : (JSON value)
string
byte
number
Array (list)
Object (dict)

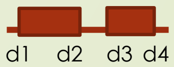
NameValue

{ ‘Paris’ : [2,4, 48,9] }

Object

{‘object name’: object value }

TimeSlot



[[[d1,d2]], [[d3,d4]]]

Property

{‘char’:’PM10, ‘unit’: ‘kg/m3’, …}

(Char -> i. e. BLE characteristic)

6 – Ilist extension

- **Observation**
  - Ilist specialization with three main indexes :
    - Datation index (Timeslot), Location index (coordinate), Property
  - Conformance with ISO 19156 : Observation & Measurement

- **Sensor acquisition**
  - Integration of Bluetooth Environmental Sensing Profile (extension in 2021)
  - Reduced exchange format for micro-controllers

- **Open-data**
  - Tool to define data structuring (e.g. tabular data)
  - Consistency measurement tool (e.g. check data model cardinalities)

Appendix

Concepts and principles

Detailed presentation

1 - Index analysis

2 - Matrix generation

3 - Aggregation

4 – Format, storage

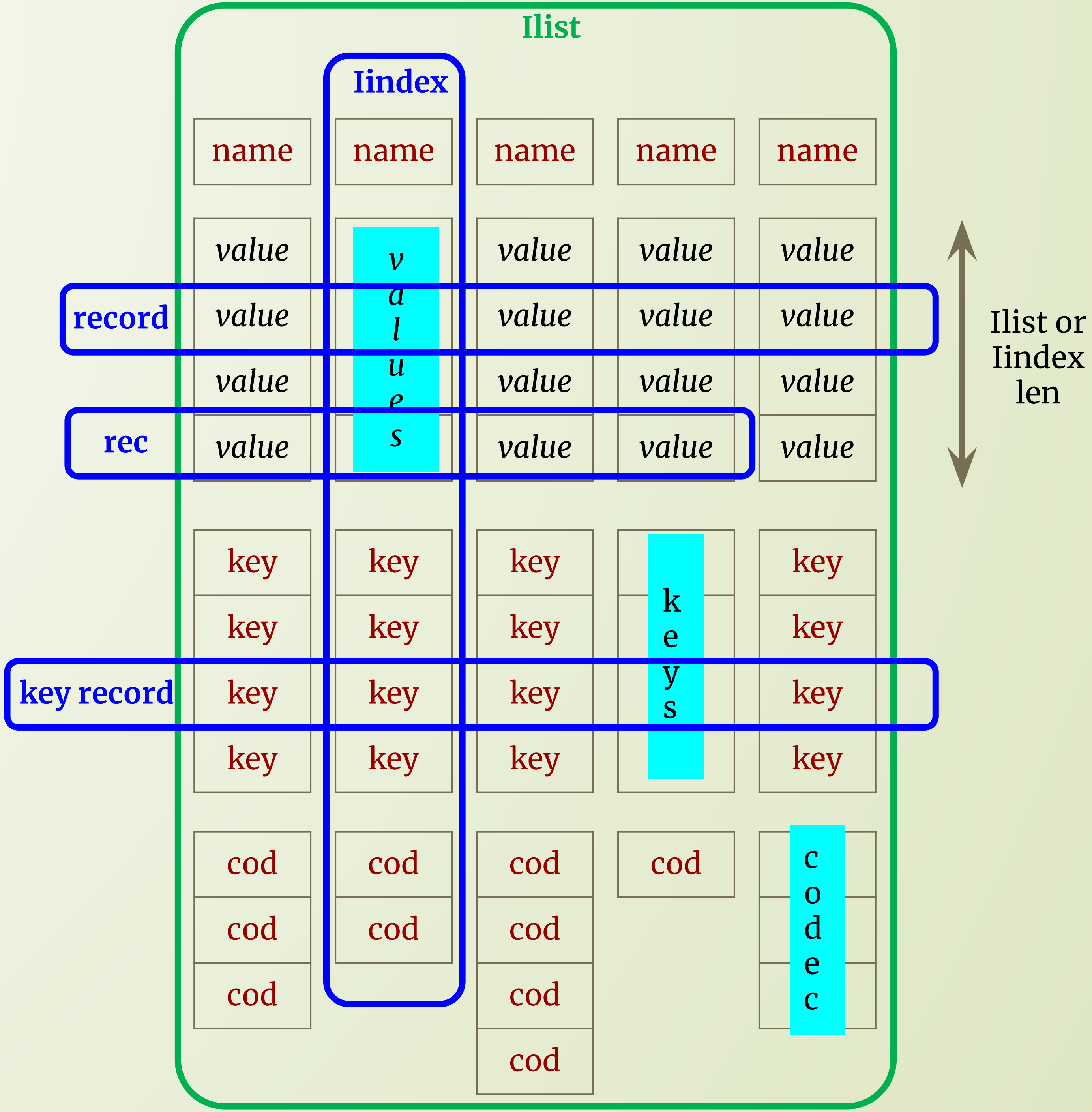
0 – Terminology

Ilist

- list of Iindex

Iindex

- name
- keys
- codec



Italic: dynamic value

1 - Iindex categories

Values	**[Anne, Paul, Anne]**	**[Anne, Anne, Anne]**	**[Anne, Paul, Anne]**
Length **(number of values)**	**3**	**3**	**3**
Codec **(row)**	0 1 2	0	0 1
Type codec	*full*	*unique*	*default*
Property	Rate : 1 Disttomax : 0	Rate : 0 Disttomin : 0	Rate : 0 Disttomin : 0
Representation	**Codec :[Anne, Paul, Anne]** **Keys: implicit ([0,1,2])**	**Codec :[Anne]** **Keys: implicit ([0, 0, 0])**	**Codec :[Anne, Paul]** **Keys: [0, 1, 0]**

Definition :

Default codec :
list of different values

Full codec :
list of values

Indicators :

M = len(values)
m = len(set(values))
x = len(codec)

Rate : (M – x) / (M – m)
Dist to min : x - m
Dist to max : M - x

Codec typology

M = 0	null
m = M = x > 1	complete
x = 1	unique
m < M = x	full
x = m < M	default
m < x < M	mixed

A codec defines the correspondence between values and keys (e.g.) :

- *1 : Anne*
- *0 : Paul*
- *2 : John*

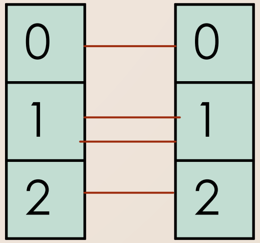
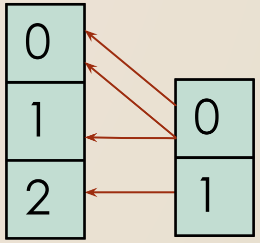
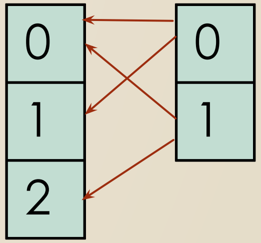
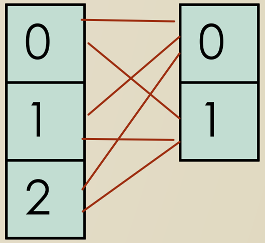
A codec may not be bijective (e.g.) :

- *0 : Anne*
- *1 : Paul*
- *2 : Anne*

1 - properties

- Any index have default codec and full codec
- Default codec are the shortest codec, full are the longest codec
- lindex with raw number is the “root lindex”, this lindex is complete

1 - Relationship categories

Values	A [Anne, Paul, John, Paul] B [25, 26, 15, 26]	[Anne, Paul, Anne, Lea] [25, 25, 25, 12]	[Anne, Paul, Anne, Lea] [25, 25, 12, 12]	[Anne, Anne, Paul, Paul, Lea, Lea] [25, 12, 25, 12, 25, 12]
Codec (row)	 A B	 B derived from A A derive B	 B linked from A A link B	 A B
Type	coupled	derived (asymmetrical)	linked (asymmetrical)	crossed
Property	Distrate : 0 Disttomin : 0 diff : 0	Distrate : 0 Disttomin : 0 0 < diff < min	0 < Distrate < 1 min < dist < Max 0 ⩽ diff ⩽ min	Distrate : 1 Disttomax : 0 0 ⩽ diff < min
Keys B	Implicit (equal Keys A)	Relative to keys A	Absolute	Implicit (Matrix order)
	Codec :[25, 26, 15, 35] **Keys: implicit**	**Codec :[25, 12]** **Keys: relative** **[0,0,1]**	**Codec :[25, 12]** **Keys: absolute** **[0,0,1,1]**	**Codec :[25, 12]** **Keys: implicit** ***([0,1,0,1,0,1])***

Indicators :

distmax = $x_A * x_B$
distmin = $\max(x_A, x_B)$
diff = $\mathrm{abs}(x_A - x_B)$
dist = $x_{(A, B)}$

Dist rate: (dist – distmin) / (distmax – distmin)
Dist to min: dist – distmin
Dist to max: distmax - dist

Rules :

B derived from A
dist = x_A and dist > x_B
A derived from B
dist = x_B and dist > x_A
A and B coupled
dist = $x_B = x_A$
A and B crossed
dist = $x_B * x_A$

Relative derived keys :

Length:
- *length(parent.codec)*

Values:
- Keyder(parent.key(i)) = key(i)

1 - distance relationship

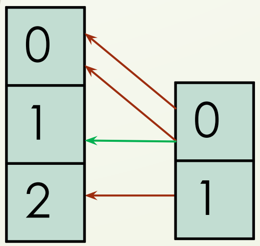
Distance (resp disttomin, resp disttomax) number of link to modify, delete or add to be coupled (resp derived, resp crossed)

	distance	**disttomin**	**disttomax**
coupled	0	0	$X_A * (X_A - 1)$
derived	$X_A - X_B$		$X_A * (X_B - 1)$
linked	$X_{(A, B)} - X_B$	$X_{(A, B)} - X_A$	$X_A * X_B - X_{(A, B)}$
crossed	$X_A * X_B - X_B$	$X_A * X_B - X_A$	0

Distance: dist - distmin + diff
Disttomin: dist - distmin
Disttomax: distmax - dist

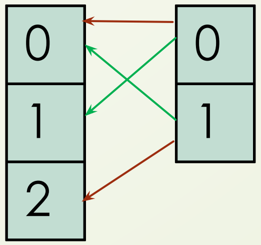
Rate: distance / (distmax - distmin + diff)
Ratemin: (dist - distmin) / (distmax - distmin)
Ratemax: dist / distmax

[Anne, Paul, Anne, Lea]
[25, 25, 25, 12]



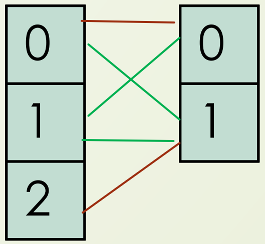
Distmax : 6
Distmin : 3
Diff : 1
Dist : 3
Distance: 1
Disttomin: 0
Disttomax:3

[Anne, Paul, Anne, Lea]
[25, 25, 12, 12]



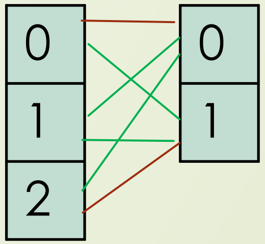
Distmax : 6
Distmin : 3
Diff : 1
Dist : 4
Distance: 2
Disttomin: 1
Disttomax:2

[Anne, Anne, Paul, Paul, Lea]
[25, 12, 25, 12, 12]



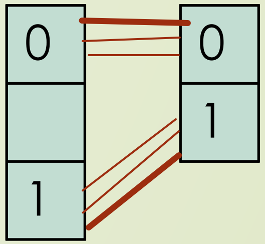
Distmax : 6
Distmin : 3
Diff : 1
Dist : 5
Distance : 3
Disttomin: 2
Disttomax:1

[Anne, Anne, Paul, Paul, Lea, Lea]
[25, 12, 25, 12, 25, 12]



Distmax : 6
Distmin : 3
Diff : 1
Dist : 6
Distance : 4 (maxi)
Disttomin: 3
Disttomax:0

[Anne, Anne, Anne, Lea, Lea, Lea]
[25, 25, 25, 12, 12, 12]



Distmax : 4
Distmin : 2
Diff : 0
Dist : 2
Distance : 0 (mini)
Disttomin: 0
Disttomax:2

1 - relationship properties

- Type and Indicators are independent of Values (order or value) and dependant of Codec and Keys

- If one index is complete, all the indexes are derived or coupled from it
- If one index is unique, it is derived from all other indexes

- If A is derived (coupled) from B and B is derived (coupled) from C, A is derived (coupled) from C and diff(A,C) = diff(A,B) + diff(B,C)

- If A and B are coupled, all the relationships with other indexes are identical

- If A and B are crossed and C is derived (coupled) from A: B and C are crossed
- If A and B are crossed: $x_A * x_B \leqslant M_A$

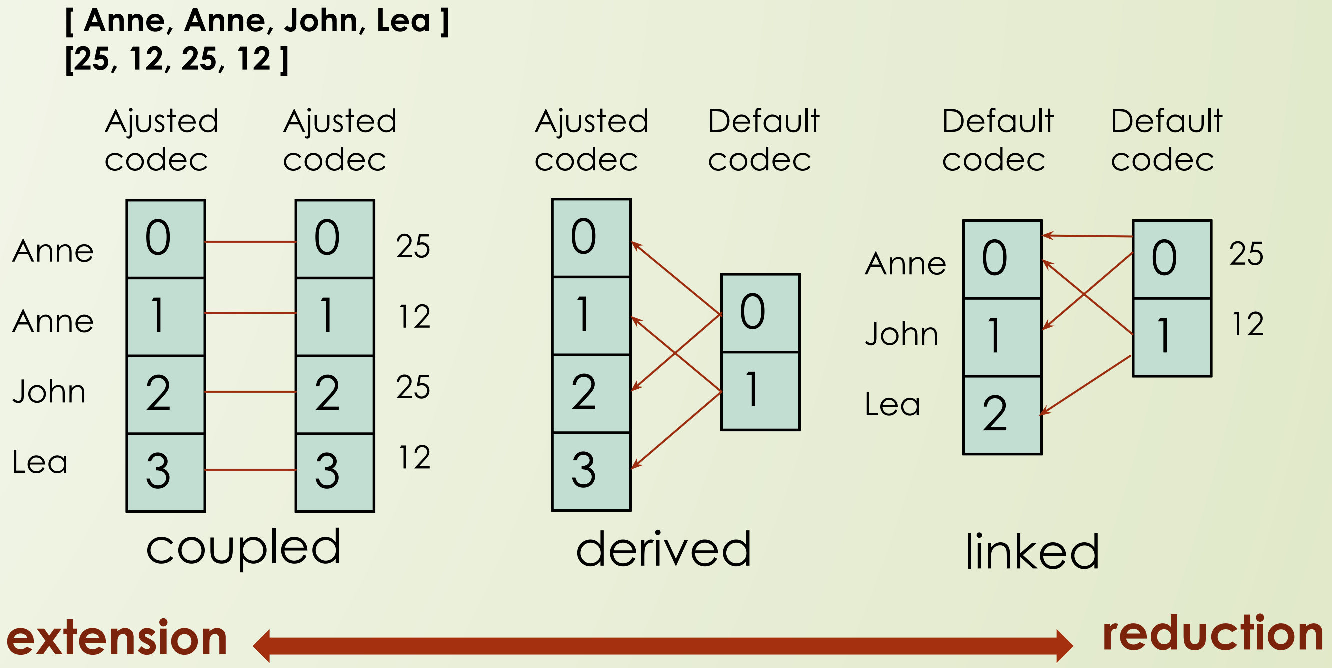
- **Keys can be deduced with coupled relationship**
  - A and B are coupled => keys(B) = keys(A)
- **Keys can be reduced with derived relationship**
  - B is derived from A => len(keys(B)) = len(codec(A))

1 – Relationship adjustment

- **Codec reduction / extension**
  - Codec changed
  - Values unchanged

Reduction is useful to minimize codec size

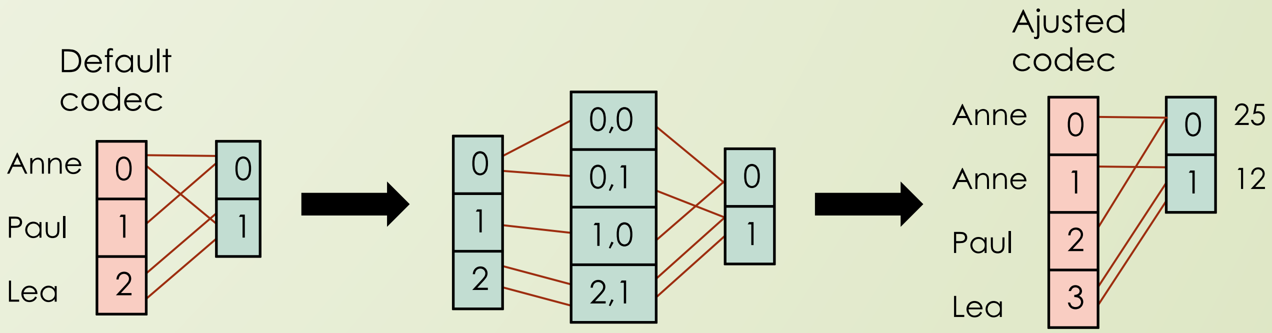
Extension is useful to increase values readability (like csv data)



[Anne, Anne, John, Lea]
[25, 12, 25, 12]

- **Codec adjustment**
  - Codec is adjusted to the other codec
  - Other index is derived or coupled to the adjusted index
  - If A is derived from B and if B is adjusted to C, A is still derived from B

Keys can be deduced from keys parent

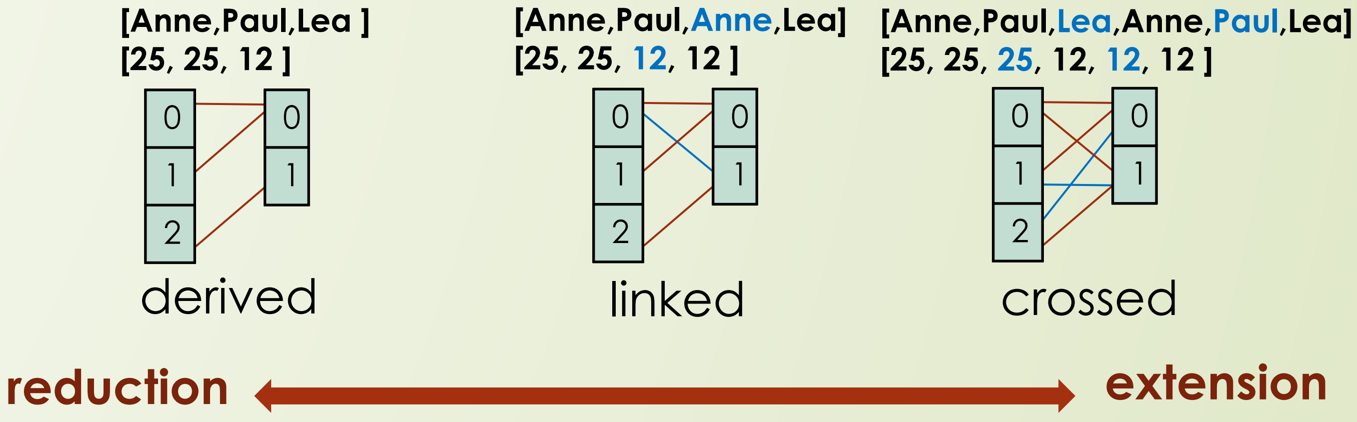


1 – Relationship adjustment

- **Values reduction / extension**
  - Codec unchanged
  - Values changed

Extension is useful to generate matrix

Reduction is useful to increase codec readability



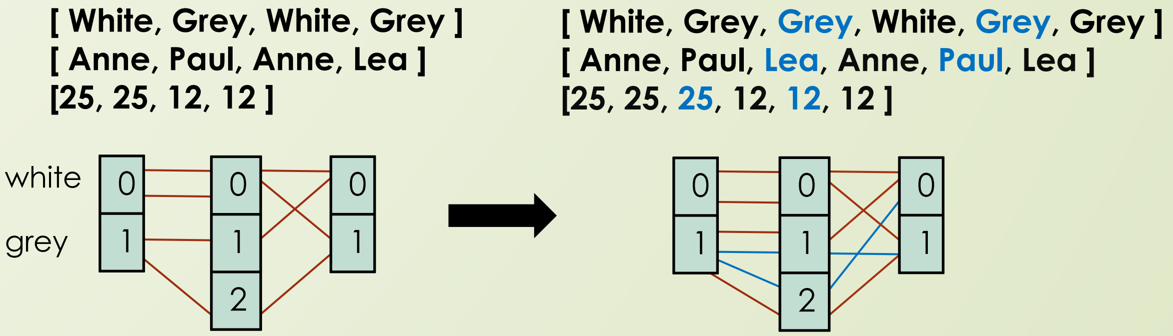
[Anne,Paul,Lea]
[25, 25, 12]

[Anne,Paul,Anne,Lea]
[25, 25, 12, 12]

[Anne,Paul,Lea,Anne,Paul,Lea]
[25, 25, 25, 12, 12, 12]

- **Propagation**
  - Values reduction / extension can be propagated to derived or coupled indexes

Extension can't be propagated to crossed or linked Indexes.



[White, Grey, White, Grey]
[Anne, Paul, Anne, Lea]
[25, 25, 12, 12]

[White, Grey, Grey, White, Grey, Grey]
[Anne, Paul, Lea, Anne, Paul, Lea]
[25, 25, 25, 12, 12, 12]

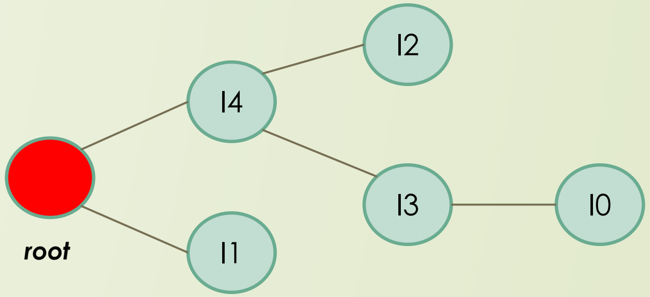
2 – Ilist

- **Ilist structure**
  - An Ilist object is a set of Iindex with the same length
  - Ilist have a hidden Iindex : **root Iindex**
  - Iindex are not ordered

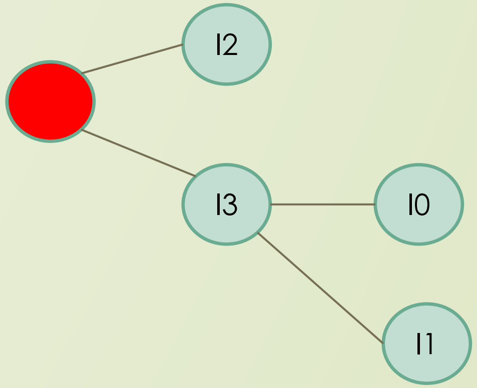
- **Ilist partition**
  - A **partition** is a set of Iindex where each root value is associated to a single combination of Iindex key (coordinate structure / multi dimensional array)
  - Three categories of Iindex are associated with a partition :
    - **Primary Iindex** : included in the partition
    - **Secondary Iindex** : child Iindex of primary or secondary Iindex
    - **Variable Iindex** : parent Iindex of primary Iindex + parent or child Iindex of variable Iindex
  - The **default partition** is the partition with the largest size
  - The **dimension** of an Ilist is the default partition size

2 – Ilist properties

- **Ilist derived tree**
  - Each index is derived (coupled) from at least one Iindex (the root Iindex)
  - An Ilist can be represented by a hierarchical tree structure
    - Nodes are Iindex
    - Root is root Iindex
    - Parent node is the deriving Iindex with minimal diff

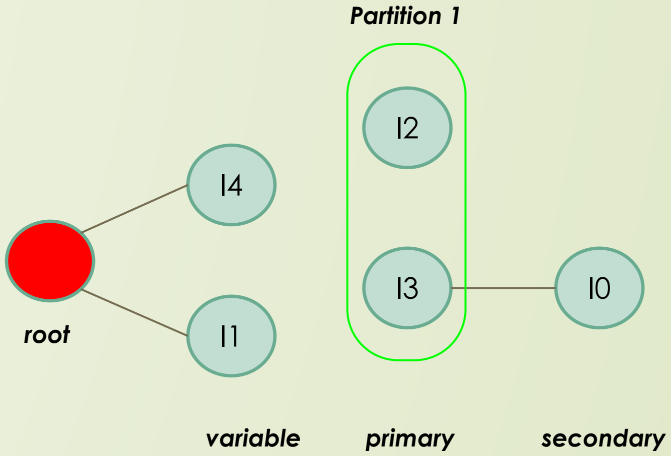


- **Ilist distance tree**
  - An Ilist can be represented by a hierarchical tree structure
    - Nodes are Iindex
    - Root is root Iindex
    - Parent node is the Iindex with minimal distance and with higher codec length



2 – Ilist properties

- **Ilist partition**
  - A set of Iindex is a partition if :
    - Each Iindex is crossed with each other
    - The product of Iindex codec length is equal to the length of the Ilist
    - The set is 'consistent' (each record is unique)
  - An Ilist have at least one implicit partition (the root partition)



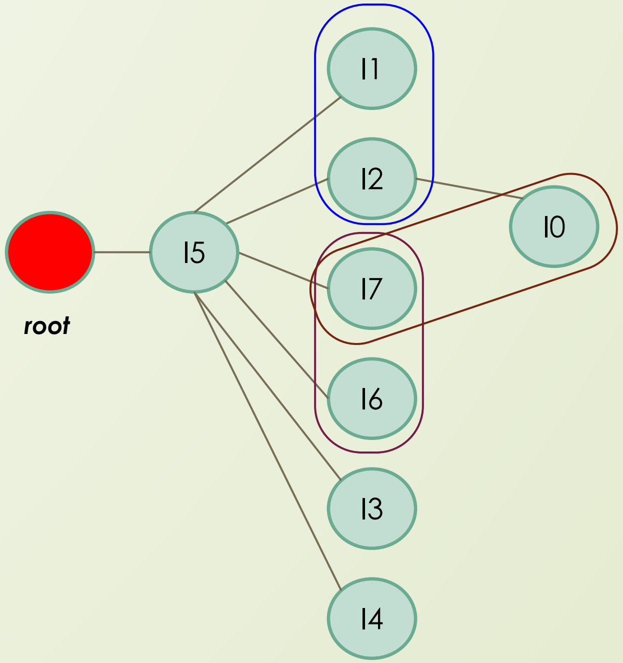
- **Properties**
  - **A multi dimensional array is associated to each partition**
  - **Keys data may be implicit for primary indexes**
  - **Dimension can be reduced by codec extension**
  - **Dimension can be increased by values extension**
  - **In a root partition, all the Iindex are secondary, the dimension is 0 (the primary Iindex is the root Iindex)**

2 - Partition example

```
["plants",    ["fruit", "fruit", "fruit", "fruit", "vegetable", "vegetable", "vegetable", "vegetable"]]
["quantity",  ["1 kg", "10 kg", "1 kg", "10 kg", "1 kg", "10 kg", "1 kg", "10 kg"]]
["product",   ["apple", "apple", "orange", "orange", "peppers", "peppers", "banana", "banana"]]
["price",     [1, 10, 2, 20, 1.5, 15, 1, 1.5]]
["group",     ["fruit 1", "fruit 10", "fruit 1", "veget", "veget", "veget", "veget", "veget"]]
["id",        [1001, 1002, 1003, 1004, 1005, 1006, 1007, 1008]]
["supplier",  ["sup1", "sup1", "sup1", "sup2", "sup2", "sup2", "sup2", "sup1"]]
["location",  ["fr", "gb", "es", "ch", "gb", "fr", "es", "ch"]]
```

Derived tree :

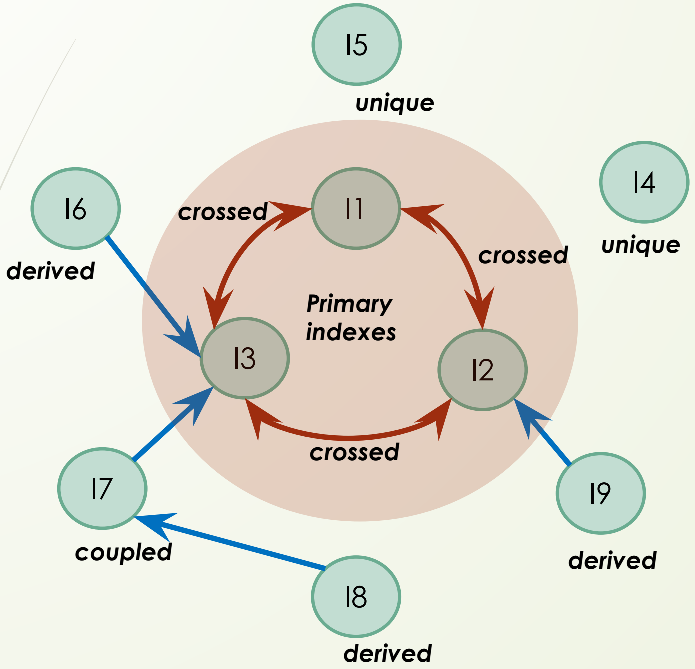
```
-1: root (8)
    5 : id (8)
        1 : quantity (2)
        2 : product (4)
            0 : plants (2)
        3 : price (6)
        4 : group (3)
        6 : supplier (2)
        7 : location (4)
```



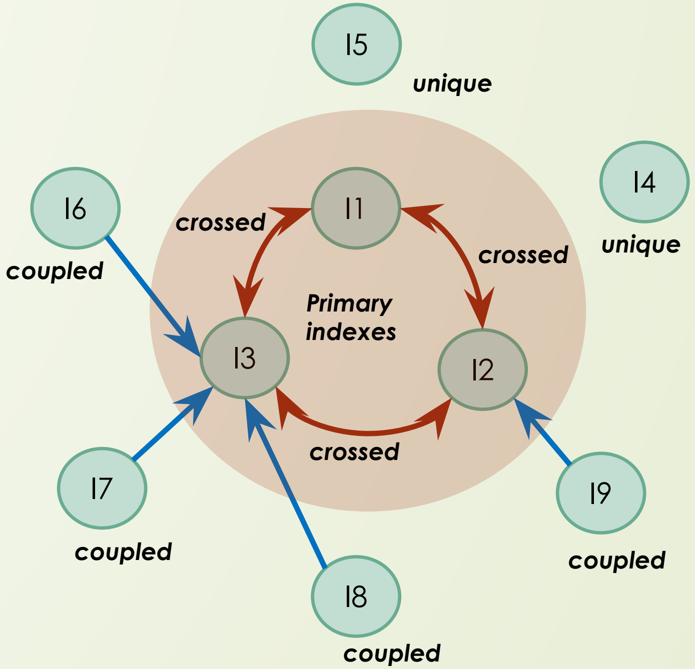
Partition :

[(0, 7), (6, 7), (1, 2)]

2 – Primary Structure



Canonical structure (default codec)



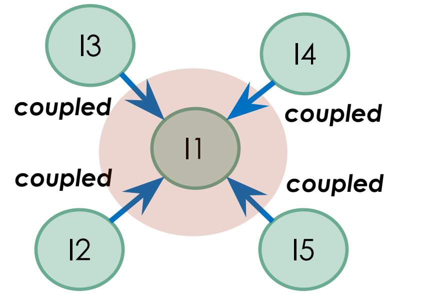
Complete indexed structure (adjusted codec and values)

In a canonical format, Keys are:

- Implicit for Primary, Unique and Coupled indexes
- Relative for Derived indexes

In a complete indexed format, Keys are all implicit

- **Properties**
  - Each Ilist has a **canonical structure** (at least one primary index)
  - **Complete data** is obtained by crossing all the primary indexes (values extension)
  - Complete Ilist can be transformed in **Matrix** (coupled secondary indexes)
  - **CSV format** is a canonical structure with one primary index and any coupled indexes, all indexes have full codec



CSV format

2 - Example

3 columns are linked

- Full name
- Course
- Examen

3 columns are derived

- First name
- Last name
- Group

1 column is coupled

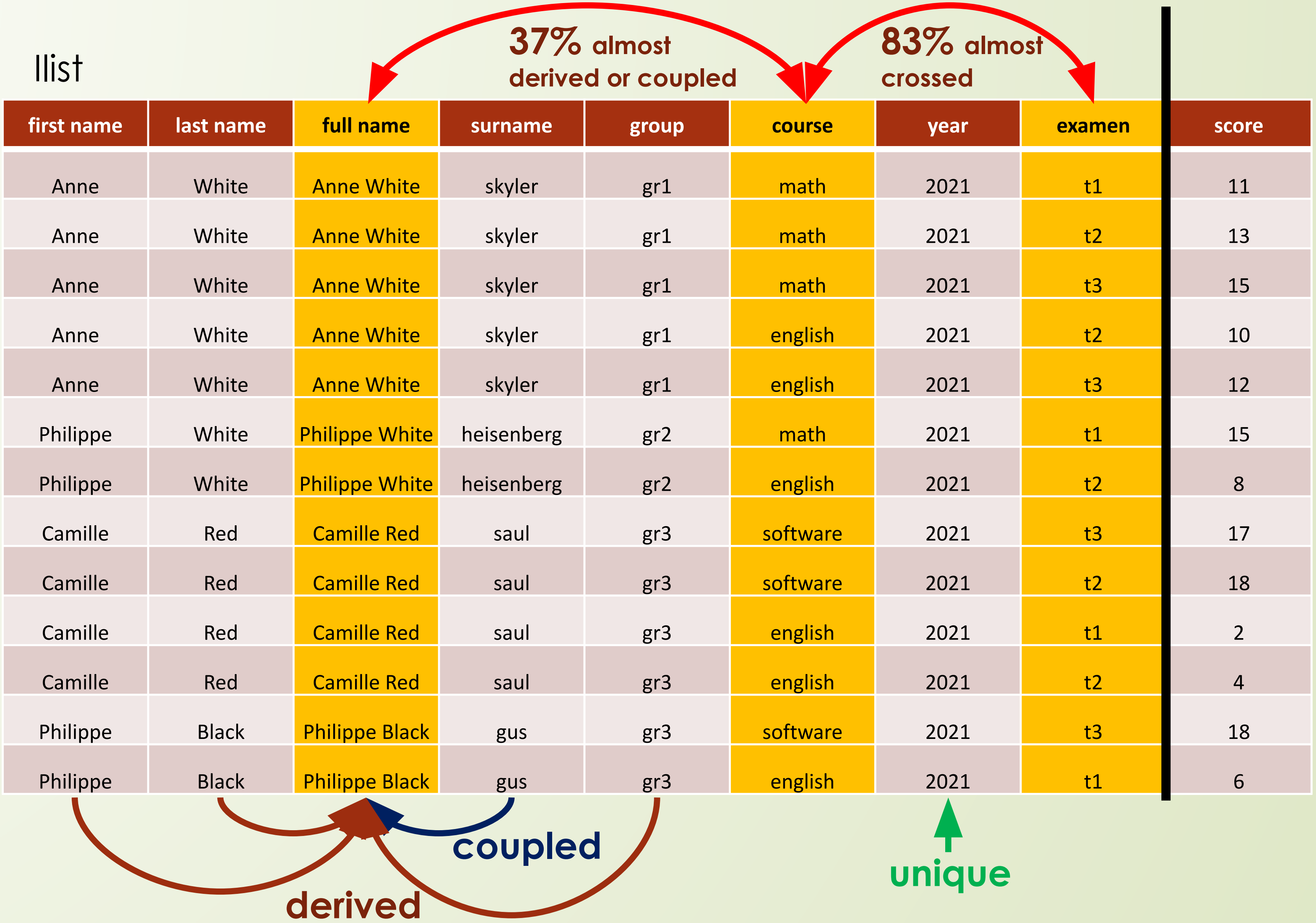
- Surname

1 column is unique

- Year

ratio

- Name – Course : 37,5 %
- Name – Examen : 62,5 %
- Course – Examen : 83,7 %

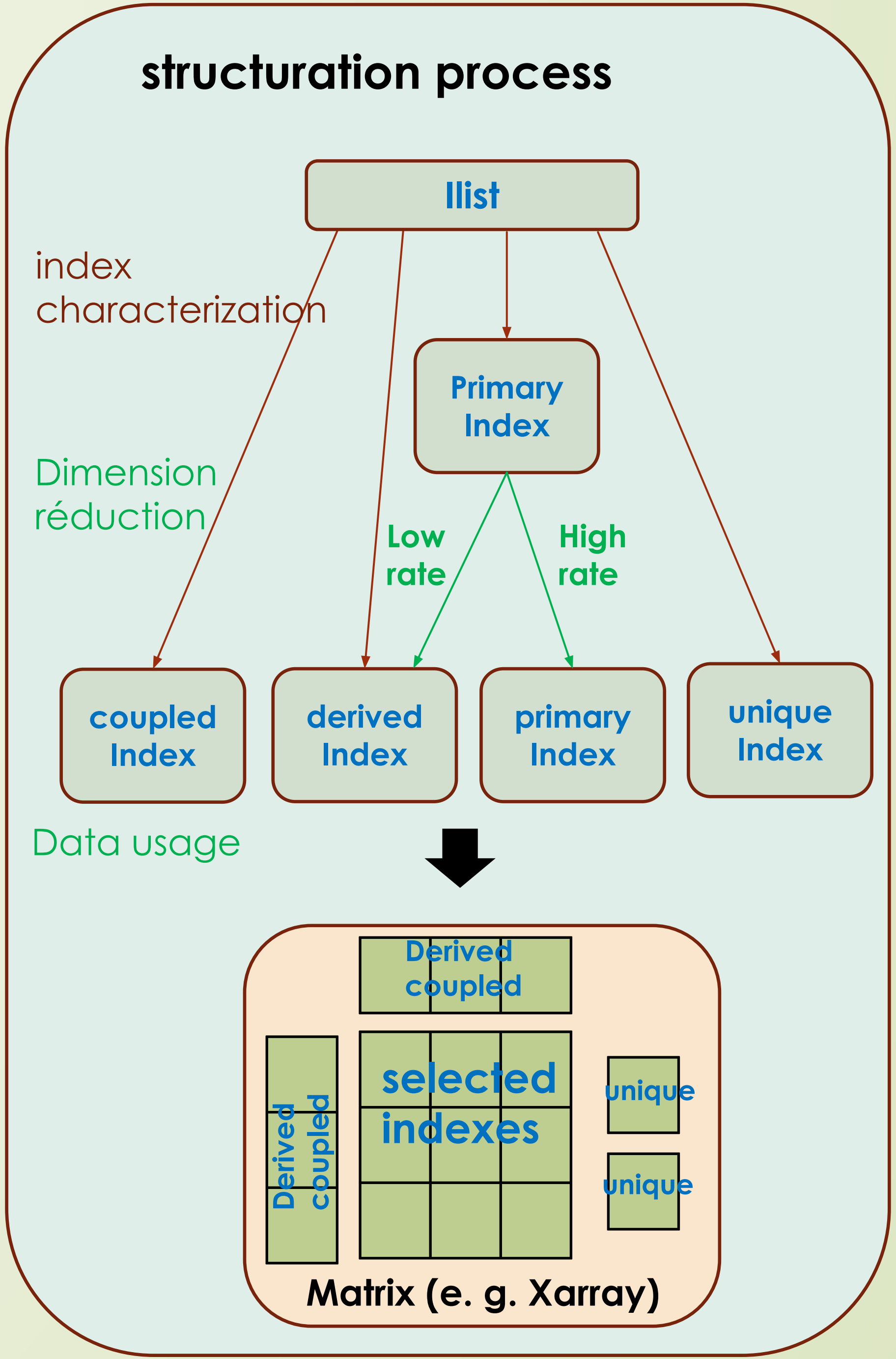


llist

first name	last name	full name	surname	group	course	year	examen	score
Anne	White	Anne White	skyler	gr1	math	2021	t1	11
Anne	White	Anne White	skyler	gr1	math	2021	t2	13
Anne	White	Anne White	skyler	gr1	math	2021	t3	15
Anne	White	Anne White	skyler	gr1	english	2021	t2	10
Anne	White	Anne White	skyler	gr1	english	2021	t3	12
Philippe	White	Philippe White	heisenberg	gr2	math	2021	t1	15
Philippe	White	Philippe White	heisenberg	gr2	english	2021	t2	8
Camille	Red	Camille Red	saul	gr3	software	2021	t3	17
Camille	Red	Camille Red	saul	gr3	software	2021	t2	18
Camille	Red	Camille Red	saul	gr3	english	2021	t1	2
Camille	Red	Camille Red	saul	gr3	english	2021	t2	4
Philippe	Black	Philippe Black	gus	gr3	software	2021	t3	18
Philippe	Black	Philippe Black	gus	gr3	english	2021	t1	6

2 – Structuration process

- **Objectives**
  - Data understanding
  - Inconsistent data identification
  - Size reduction
  - Transfer to analysis tools (e.g. Pandas, Xarray)
- **Analysis**
  - **Index characterization**
    - Identification of primary indexes
    - Association of secondary indexes to primary indexes
  - **Linked indexes analysis**
    - Low rate (i.e. < 0,1) = almost derived index
      -> transform to derived index (codec extension)
      -> or values correction
    - High rate (i.e. > 0,9) = almost crossed index
      -> transform to crossed index
      -> or values correction
- **Data usage**
  - **Dimension reduction (if necessary)**
    - Primary index merging (rather low rate)
  - **Export**
    - Matrix generation
    - Storage



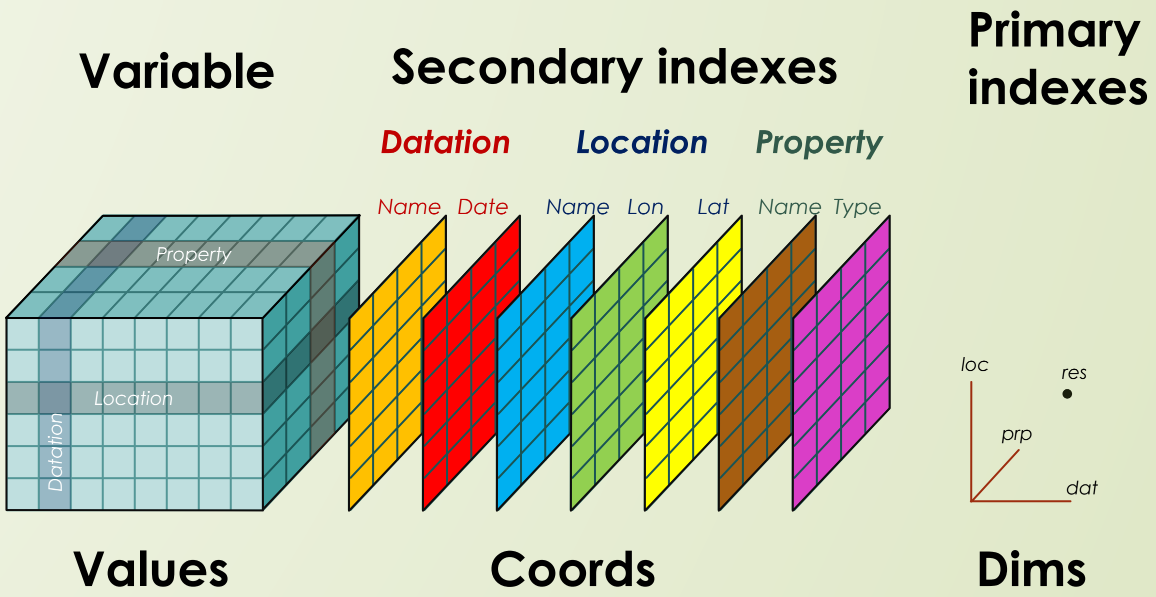
2 - Example : Xarray – mapping

> Xarray

- Values : data matrix(ex. numpy ndarray)
- Coords : list of indexes: (dims, data, attrs)
- Dims : names of dimensions
- Attrs : attribute dictionary (data or coord)
- Name

> Ilist Mapping

- Dims : Primary indexes
- Values : Variable values
- Coords : Secondary indexes
- Attrs : Unique indexes
- Name : Ilist name



Variable

Secondary indexes

Primary indexes

Values

Coords

Dims

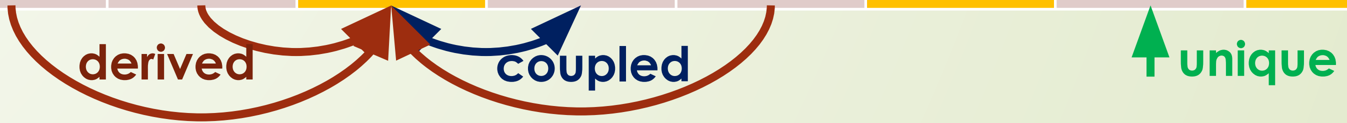
2 - Example

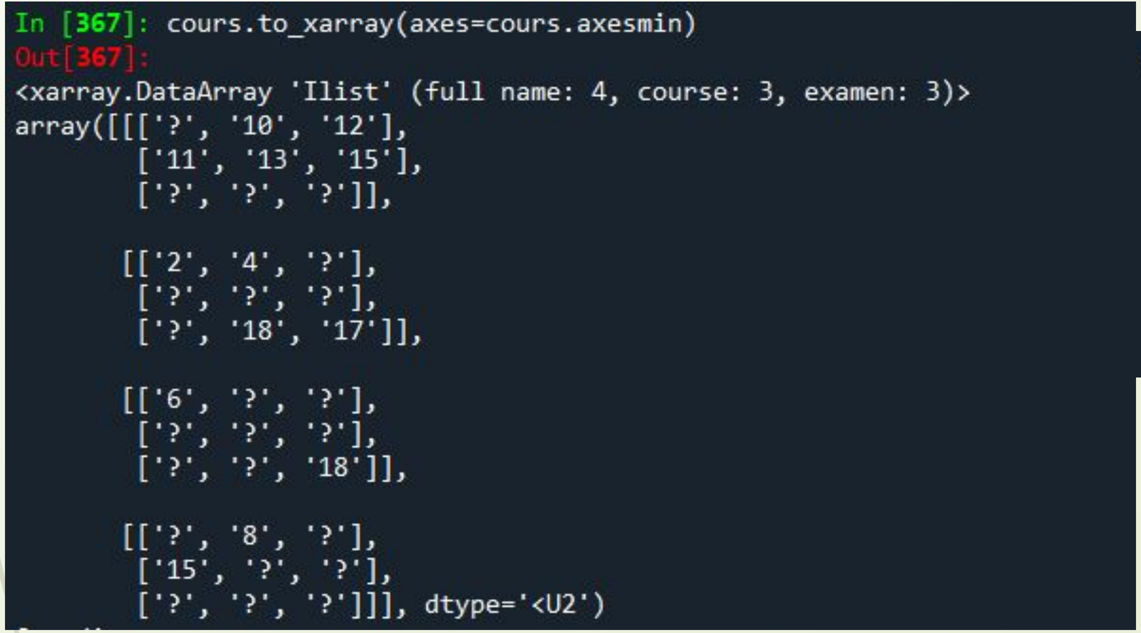
to_xarray function :

- Primary crossed (values extension)
- Secondary coupled (full codec)

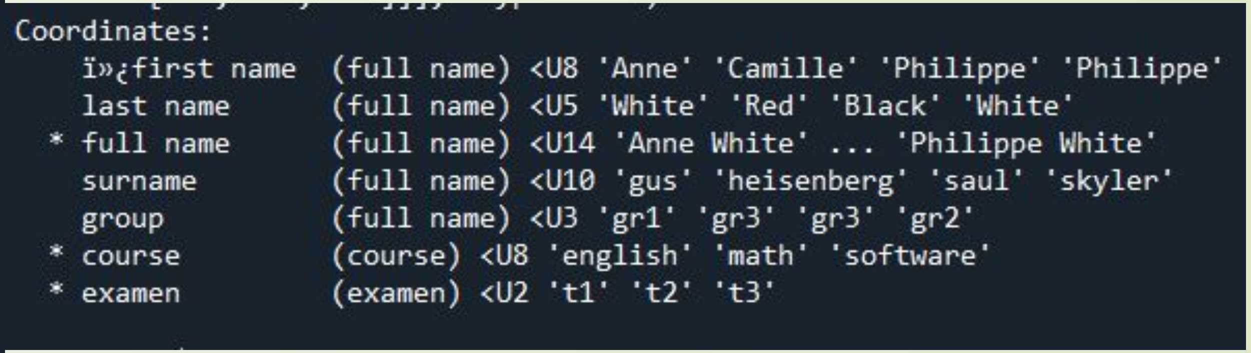
first name	last name	full name	surname	group	course	year	examen	score
Anne	White	Anne White	skyler	gr1	english	2021	t1	-
Anne	White	Anne White	skyler	gr1	english	2021	t2	10
Anne	White	Anne White	skyler	gr1	english	2021	t3	12
Anne	White	Anne White	skyler	gr1	math	2021	t1	11
Anne	White	Anne White	skyler	gr1	math	2021	t2	13
Anne	White	Anne White	skyler	gr1	math	2021	t3	15
Anne	***White***	***Anne White***	***skyler***	***gr1***	***software***	***2021***	***t1***	-
Anne	***White***	***Anne White***	***skyler***	***gr1***	***software***	***2021***	***t2***	-
Anne	***White***	***Anne White***	***skyler***	***gr1***	***software***	***2021***	***t3***	-

completed



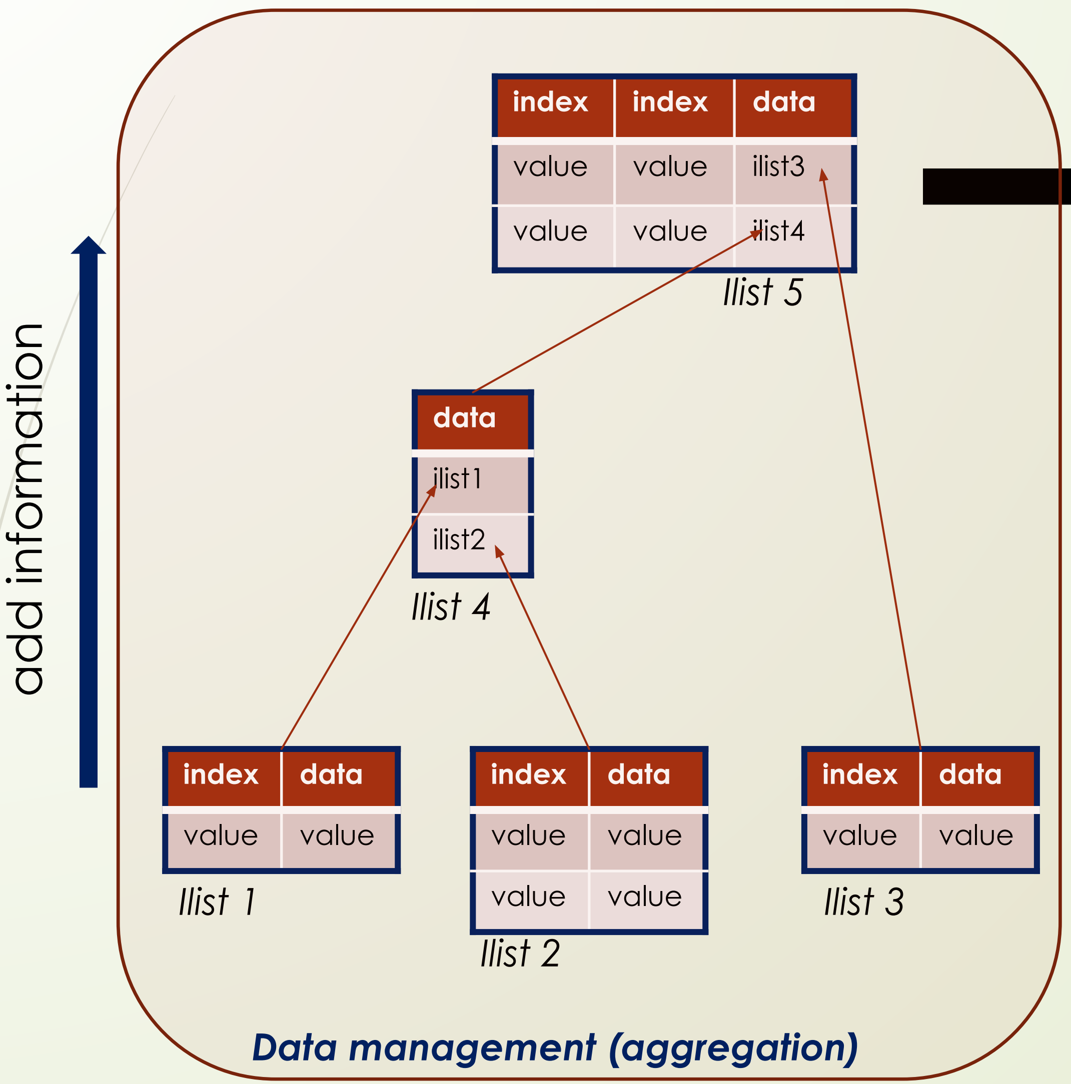


```
In [367]: cours.to_xarray(axes=cours.axesmin)
Out[367]:
<xarray.DataArray 'Ilist' (full name: 4, course: 3, examen: 3)>
array([[['?', '10', '12'],
        ['11', '13', '15'],
        ['?', '?', '?']],

       [['2', '4', '?'],
        ['?', '?', '?'],
        ['?', '18', '17']],

       [['6', '?', '?'],
        ['?', '?', '?'],
        ['?', '?', '18']],

       [['?', '8', '?'],
        ['15', '?', '?'],
        ['?', '?', '?']]], dtype='<U2')
```



```
Coordinates:
    ï»¿first name   (full name) <U8 'Anne' 'Camille' 'Philippe' 'Philippe'
    last name      (full name) <U5 'White' 'Red' 'Black' 'White'
  * full name      (full name) <U14 'Anne White' ... 'Philippe White'
    surname        (full name) <U10 'gus' 'heisenberg' 'saul' 'skyler'
    group          (full name) <U3 'gr1' 'gr3' 'gr3' 'gr2'
  * course         (course) <U8 'english' 'math' 'software'
  * examen         (examen) <U2 't1' 't2' 't3'
```

3 - Building process



index	index	data
value	value	ilist3
value	value	ilist4

Ilist 5

data
ilist1
ilist2

Ilist 4

index	data
value	value

Ilist 1

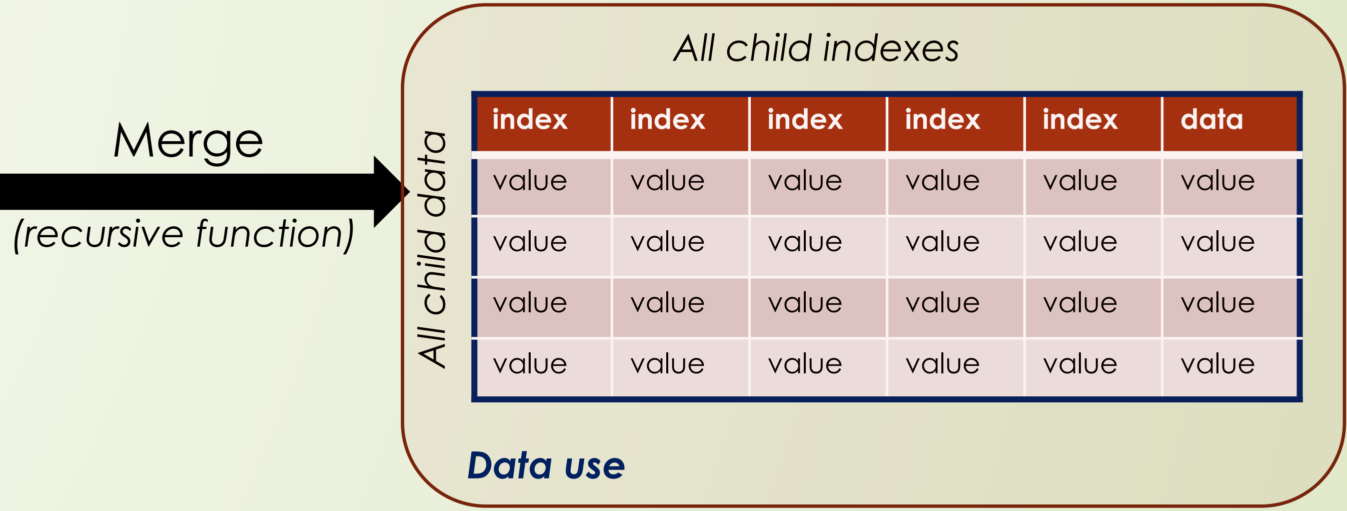
index	data
value	value
value	value

Ilist 2

index	data
value	value

Ilist 3

Data management (aggregation)



Merge

(recursive function)

All child indexes

All child data

index	index	index	index	index	data
value	value	value	value	value	value
value	value	value	value	value	value
value	value	value	value	value	value
value	value	value	value	value	value

Data use

- **Process adapted to organizations**
- **Add information without altering**
- **Separation of management and use**

3 - Example

IndexSet | Data

aw

course	year	examen	score
math	2021	t1	11
math	2021	t2	13
math	2021	t3	15
english	2021	t2	10
english	2021	t3	12

pw

course	year	examen	score
math	2021	t1	15
english	2021	t2	8

cr

course	year	examen	score
software	2021	t3	17
software	2021	t2	18
english	2021	t1	2
english	2021	t2	4

pb

course	year	examen	score
software	2021	t3	18
english	2021	t1	6

total

first name	last name	full name	surname	group	file
Anne	White	Anne White	skyler	gr1	aw
Philippe	White	Philippe White	heisenberg	gr2	pw
Camille	Red	Camille Red	saul	gr3	cr
Philippe	Black	Philippe Black	gus	gr3	pb

total.merge()

first name	last name	full name	surname	group	course	year	examen	score
Anne	White	Anne White	skyler	gr1	math	2021	t1	11
Anne	White	Anne White	skyler	gr1	math	2021	t2	13
Anne	White	Anne White	skyler	gr1	math	2021	t3	15
Anne	White	Anne White	skyler	gr1	english	2021	t2	10
Anne	White	Anne White	skyler	gr1	english	2021	t3	12
Philippe	White	Philippe White	heisenberg	gr2	math	2021	t1	15
Philippe	White	Philippe White	heisenberg	gr2	english	2021	t2	8
Camille	Red	Camille Red	saul	gr3	software	2021	t3	17
Camille	Red	Camille Red	saul	gr3	software	2021	t2	18
Camille	Red	Camille Red	saul	gr3	english	2021	t1	2
Camille	Red	Camille Red	saul	gr3	english	2021	t2	4
Philippe	Black	Philippe Black	gus	gr3	software	2021	t3	18
Philippe	Black	Philippe Black	gus	gr3	english	2021	t1	6

4 – Iindex Representation

Json Example

- **Codec representation**
  - List of values (or dict key/value)

['Anne', 'Anne', 'John', 'Paul']

- **Keys representation**
  - Absolute : List of integer (index of codec value)
  - Relative : List of integer (index of other keys)
  - Implicit : Automatic list (i.e. with full codec)

[2, 2, 3] → **['John', 'John', 'Paul']**

[2, 3] → **['John', 'John', 'Paul']**

[0, 1, 2, 3] ← **if full codec**

- **Iindex /variable Formats**
  - Simple format (full codec)
  - Simple format (default codec)
  - Complete format (codec + keys)
  - Coupled format (codec + parent)
  - Derived periodic format (codec + parent)
  - Derived format (codec + parent + keys)
    - Keys = index of parent keys

['Anne', 'Anne', 'John', 'Paul', 'John']

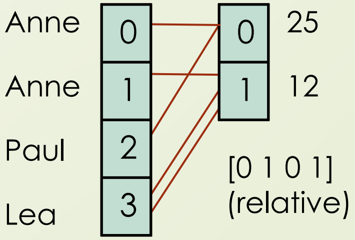
['Anne', 'John', 'Paul']

[['Anne', 'John', 'Paul'], [0, 0, 1, 2, 1]]

[['Anne', 'John', 'Paul'], parent]

[['Anne', 'John', 'Paul'], parent, [0, 0, 1, 2, 1]]

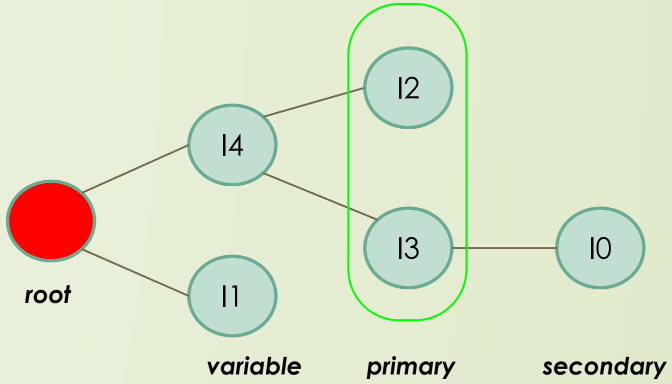
[Anne,Anne, Lea, Paul, Lea]
[12, 25, 12, 25, 12]



[0 1 0 1]
(relative)

Derived Iindex : [[25, 12], parent, [0, 1, 0, 1]] *(derived)*
Parent index : [Anne, Anne, Paul, Lea], [0, 1, 3, 2, 3]] *(complete)*

4 – Ilist representation



Mode 'full'

- **All Iindex (simple format)**
  - Codec : full
  - Parent : implicit
  - Keys : implicit

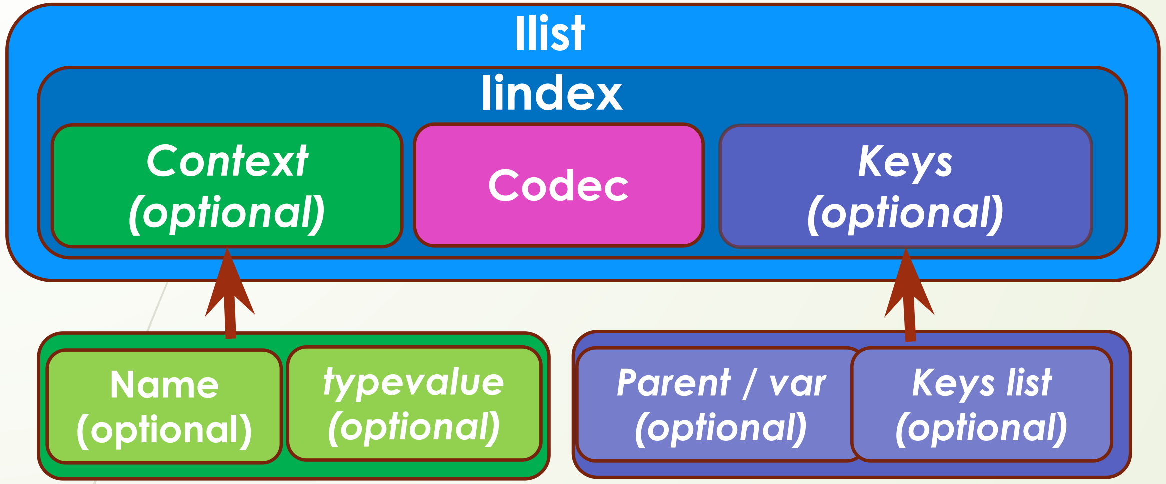
Mode 'default'

- **All Iindex (complete format)**
  - Codec : default
  - Parent : implicit
  - Keys : absolute

Mode 'optimize'

- **Primary Iindex (simple format)**
  - Codec : default
  - Parent : implicit
  - Keys : implicit
- **Variable and secondary Iindex**
  - Codec : default
  - Parent : explicit (implicit if root)
  - Keys :
    - Unique : implicit
    - Coupled : implicit
    - Derived : relative
    - Root derived : absolute

4 – JSON Representation



Ilist

Iindex

Context (optional)

Codec

Keys (optional)

Name (optional)

typevalue (optional)

Parent / var (optional)

Keys list (optional)

Ilist:	JSON Array
Iindex:	JSON Array (or JSON value if only one value and not a value Array)
Context:	JSON Object (or JSON string if only one value)
Codec:	JSON Array
Keys:	JSON Array
Name, Typevalue:	string
keys list:	JSON Array
Parent / variable:	integer (-1 for variable)

Format

Text (JSON text), Binary (CBOR)

Example Index : Name : 'team1'
Values : ['Anne', 'Anne', 'John', 'Paul', 'John']

- **Simple format (without name)**
  ['Anne', 'Anne' 'John', 'Paul', 'John']
  -> Full codec (e.g. csv format)
- **Simple format (with name)**
  ['team1', ['Anne', 'John', 'Paul']]
  -> Default codec (e.g. crossed index)
- **Complete format (with name)**
  ['team1', ['Anne', 'John', 'Paul'], [0,0,1,2,1]]
  -> Default codec, name, absolute keys
- **Coupled format (with name)**
  ['team1', ['Anne', 'John', 'Paul', 'John'], 2]
  -> Adjusted codec, parent id
- **Derived format (with name)**
  ['team1', ['Anne', 'John', 'Paul'], [2, [0,1,2,1]]]
  -> Default codec, parent id, relative keys
- **Unique format**
  ['team1', ['Anne']] (with name) **'Anne'** (without name)
  -> Default codec (= full codec)

4 – Ilist size and indicators

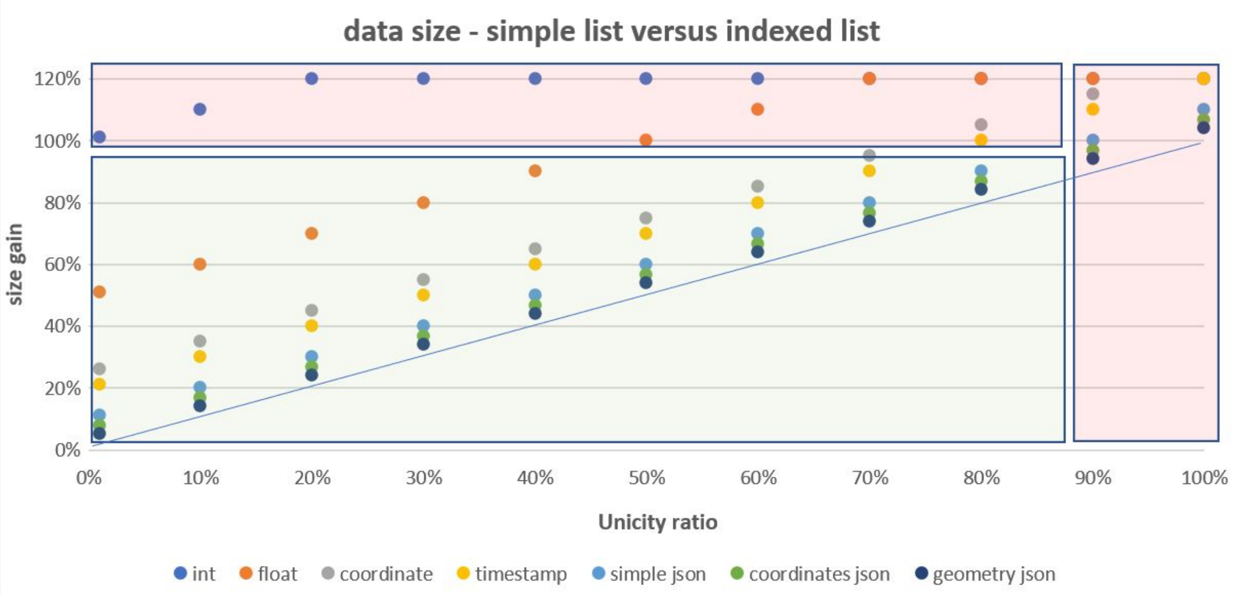
- **Maximal size (size without coding) = nv * sv**
  - nv : number of values (name included)
  - sv : mean value size = maximal size / nv
- **Minimal size (size with null coding size) = nc * sv**
  - nc : number of different values (name included)
- **Indexed size = (nv – nc) * sc + nc * sv**
  - sc: mean coding value size = (size – nc * sv) / (nv – nc)
- **Indicators**
  - **UL = nc / nv (unicity level) [0, 1] (data quality - gain maxi)**
    - UL = minimal size / maximal size
    - 1 - UL = gain maxi = (maximal size - minimal size) / maximal size
    - UL = 0 (empty data), UL = 1 (unoptimisable data)
  - **OL = sc / sv (object lightness) [0, 1] (data coding - gain ratio)**
    - OL = (indexed size - minimal size) / (maximal size - minimal size)
    - 1 - OL = Gain / Gain maxi
    - OL = 0 (maxi coding), OL = 1 (no coding)
  - **Gain = (1 – UL) * (1 – OL)**
    - Gain = (maximal size - indexed size) / maximal size
    - Gain maxi = 1 - UL
    - Gain = 0 (no coding), Gain = 1 (empty data / maxi coding)

- **Example**
  - Different data:
    - nc = nv
    - **UL = 1** (OL = 1)
  - Identical data :
    - Lines (l), Cols (c)
    - nv = l * c
    - nc = c
    - **UL = 1 / l**
  - Matrix data (n x n):
    - Lines (l) = n * n
    - Cols = 3
    - nv = 3 * n * n
    - nc = 2 * n + n * n
    - **UL = (2+n) / 3*n**
= 0.33 (if n >> 2)

4 – Ilist size and indicators

Example - simple list

- **Duplicate value**
  - [val, val, …, val, val]
  - list size : n,   val size : m
- **Coded list** (default)
  - [val, [0, 0, ..., 0, 0]
- **Indicators**
  - sv = m, nv = n
  - sc = 2n/(n-1), nc = 1
  - UL = 1/n, OL = 2n / m*(n-1)
  - Gain = (nm-m-2n) / m*n
  - n >> 1 :
    - **UL = 1/n, OL = 2/m, Gain = 1 - 2/m**



Object lightness	m	OL
int	2	1,00
float, int32	4	0,50
coordinate	8	0,25
string(10) (eg. timestamp)	10	0,20
simple json element (eg key/value)	20	0,10
structured json element (eg coordinates)	30	0,07
complex json element (eg geometry)	50	0,04

Example : Open-data - french charging point (EVSE)

7.5 Mo – 11 000 rows – 49 columns

Analysis :

Indexes : 1 coupled, 6 derived, 1 crossed, 41 linked

Canonical format : 1 crossed, 48 derived

File size :

Default :	3.7 Mo
Optimized :	2.5 Mo
CBOR optimized :	**1.7 Mo (gain : 77% !)**