Accenture / Fjord Dublin (via teleconference) 14 July 2020

Systems Theory in Design
Nodes, links, and networks

Hugh Dubberly
Dubberly Design Office

A key aspect of systems is the relationship between elements — the system's structure.

Today, we will look at three related topics:

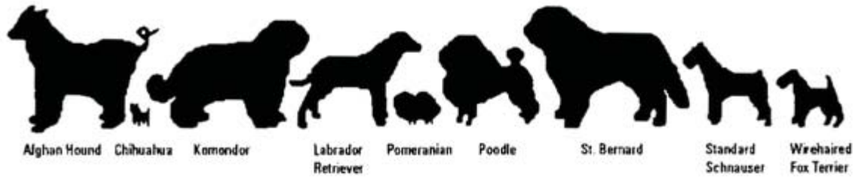
- **Information structures**
- **Communications within networks**
- **Counting and measuring**

Information Structures

Wurman offers “LATCH” as a set of organizing principles

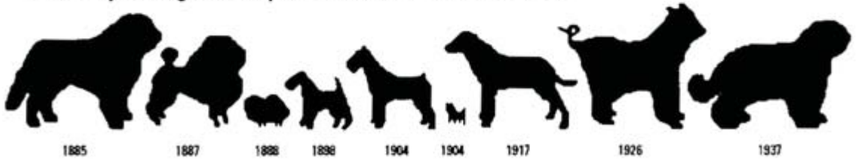
Location, Alphabet, Time, Category, or Hierarchy — a mixed list

I could organize these dogs alphabetically…

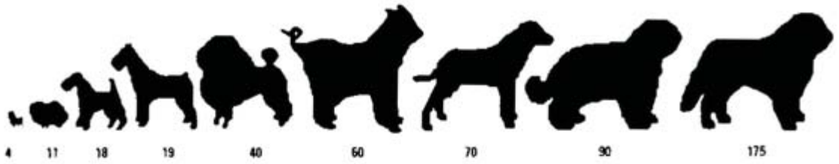


or by category (country of origin, for example)

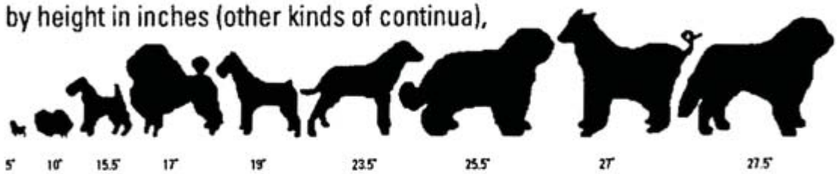
or by time (for instance, according to the year in which the breed was officially recognized by th American Kennel Club).



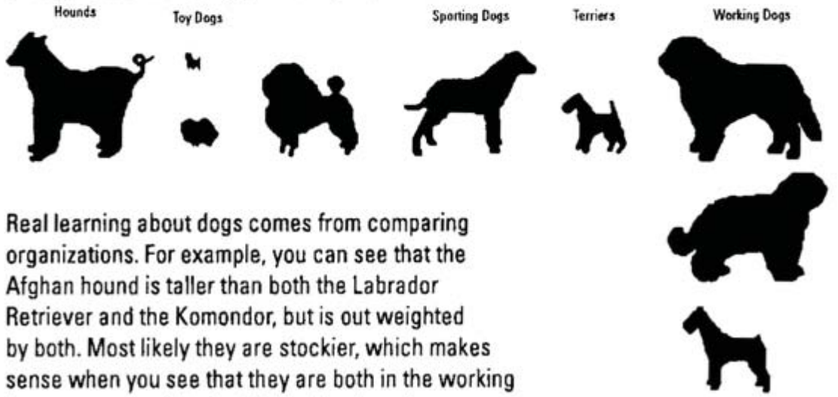
Then again, I might arrange then by weight in pounds,



by height in inches (other kinds of continua),



or by breeds as categorized by the American Kennel Club.



Real learning about dogs comes from comparing organizations. For example, you can see that the Afghan hound is taller than both the Labrador Retriever and the Komondor, but is out weighted by both. Most likely they are stockier, which makes sense when you see that they are both in the working dogs category while the Afghan is a hound.

Wurman, Richard Saul, *Information Anxiety,* Double Day, NewYork NY (1989) pg.71-72

Ethnographic Frameworks suggest ways of cataloging systems.

AEIOU	POEMS	Ax4
Activity	People	Actors
Environment	Objects	Activities
Interaction	Environment	Artifacts
Object	Messages	Atmosphere
User	Services	

Information structures decompose into half-a-dozen basic forms — “primitives”:

- Name-Value Pairs
- Nodes + Links
- Array
- Matrix
- Tree
- Web

Points or name-value pairs — x = 3.1415

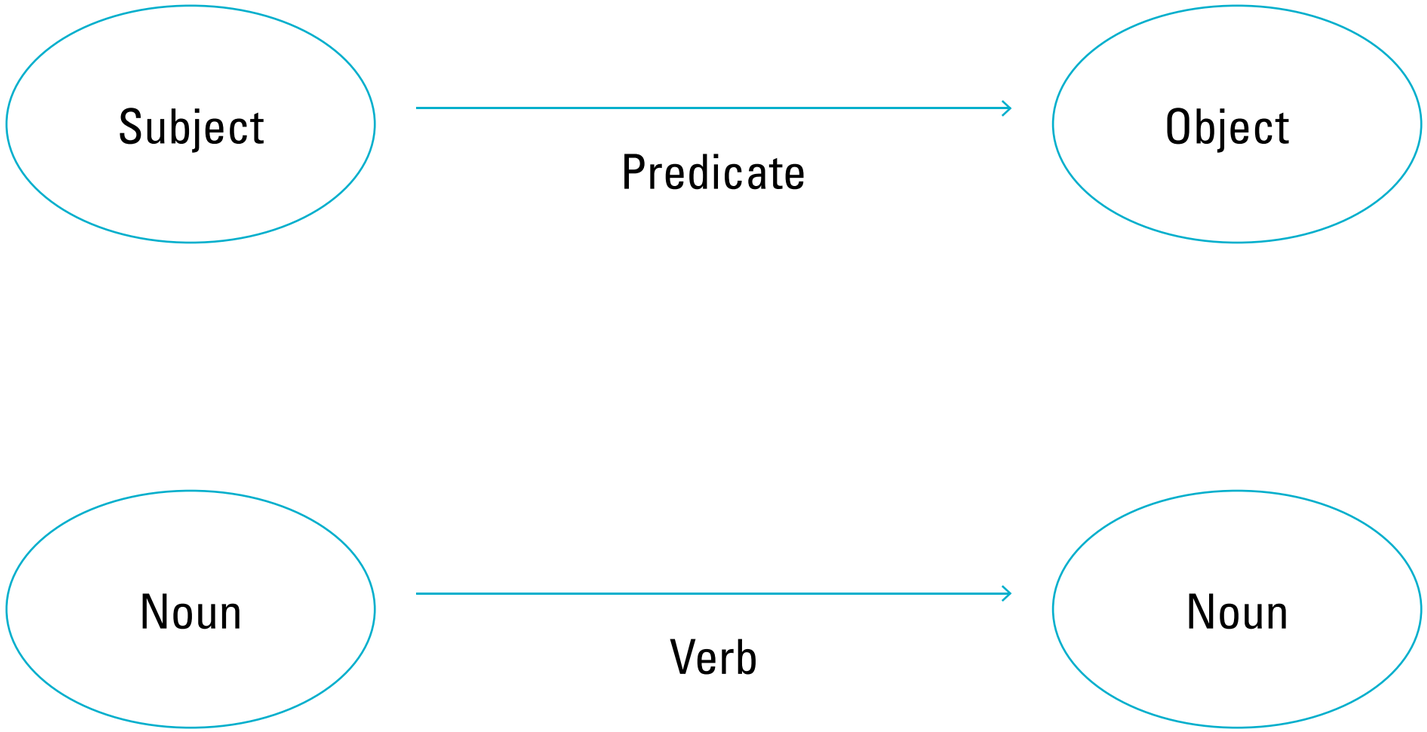
Name-Value Pairs — variable + the current instance

Key	Value
firstName	Bugs
lastName	Bunny
location	Earth

Nodes + Links — also entities + relationships

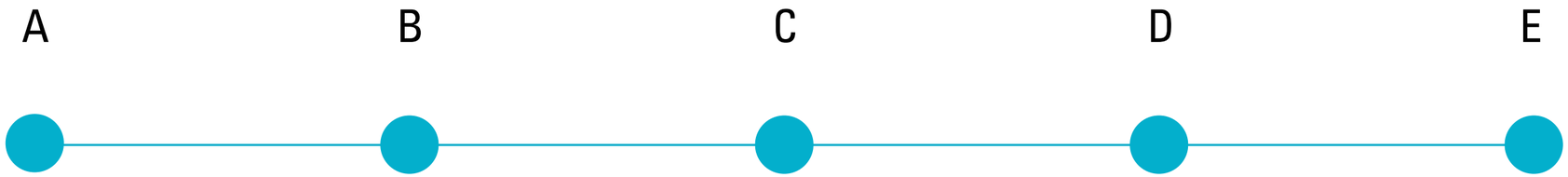
Node Link Node

RDF example — Resource Description Framework, an internet standard

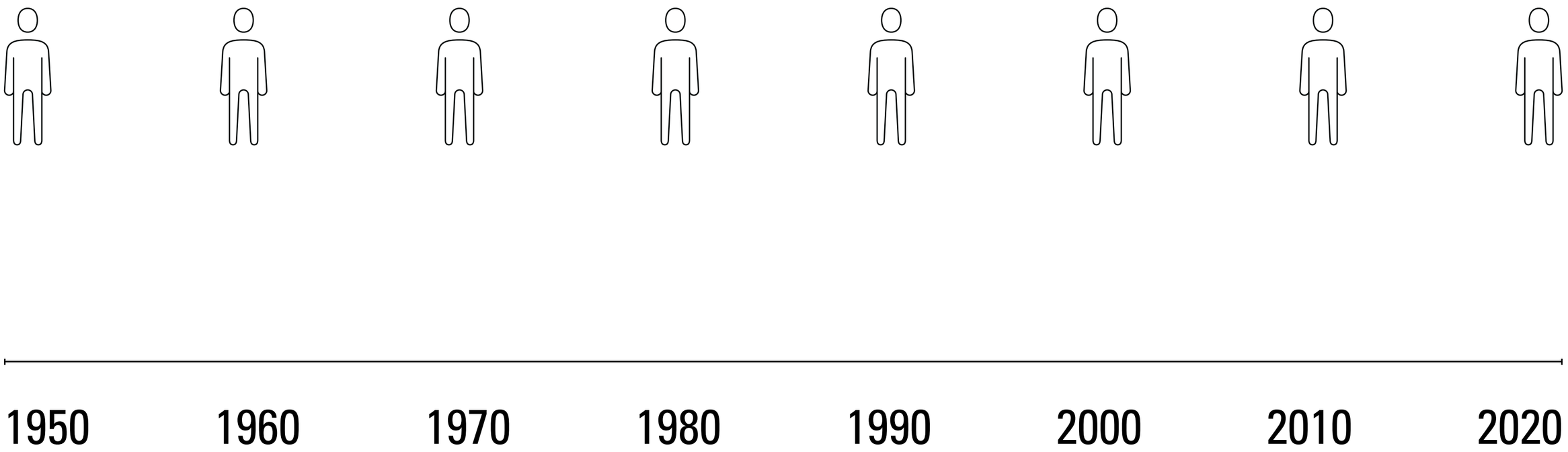


Lines or arrays

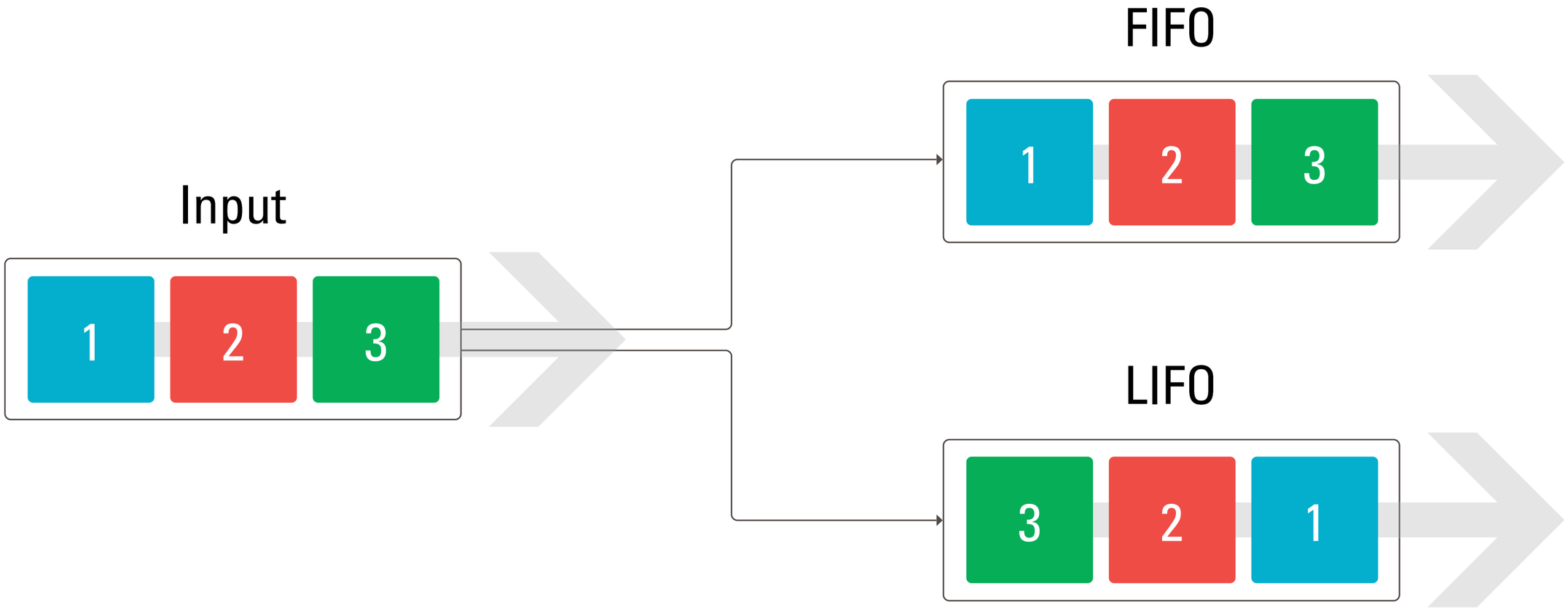
Array — a “string” or list — may be a process, journey, or path



A queue or timeline may also be thought of as an array.

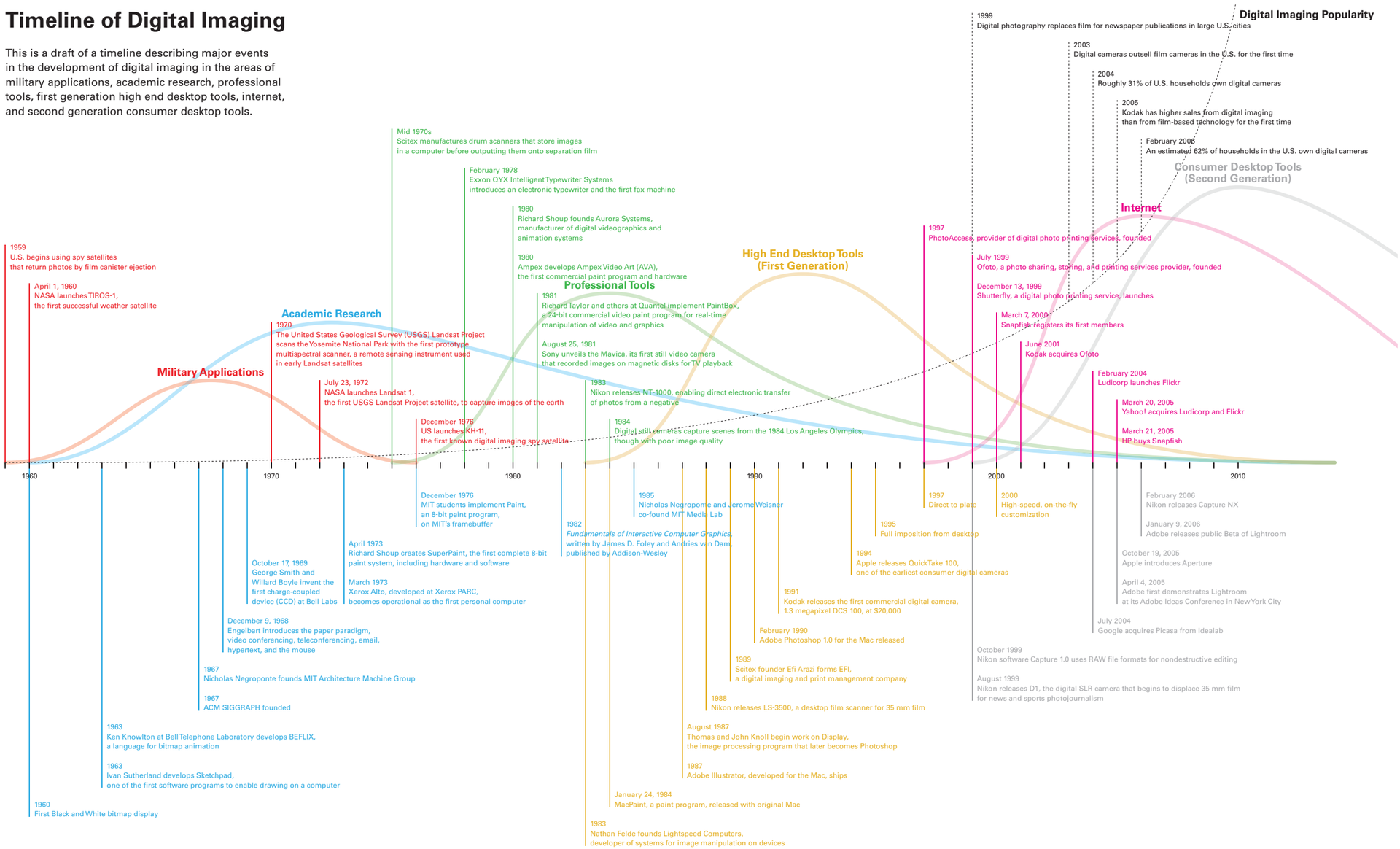


In programming, “the stack” is also an array, which may be organized
FIFO, First In, First Out
LIFO, Last In, First Out



Timeline of Digital Imaging

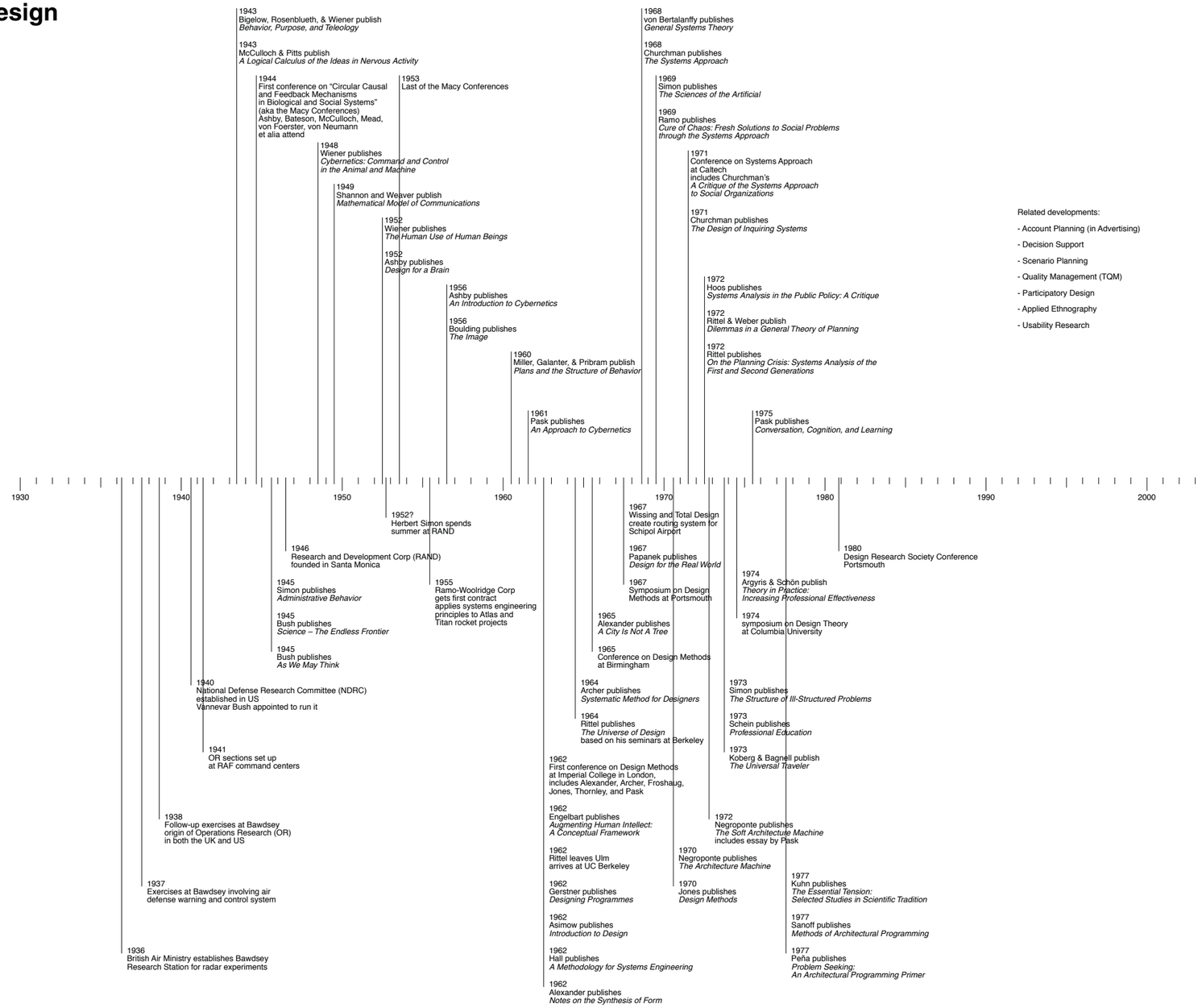
This is a draft of a timeline describing major events in the development of digital imaging in the areas of military applications, academic research, professional tools, first generation high end desktop tools, internet, and second generation consumer desktop tools.



Version 1.3
Dubberly Design Office
March 9, 2006

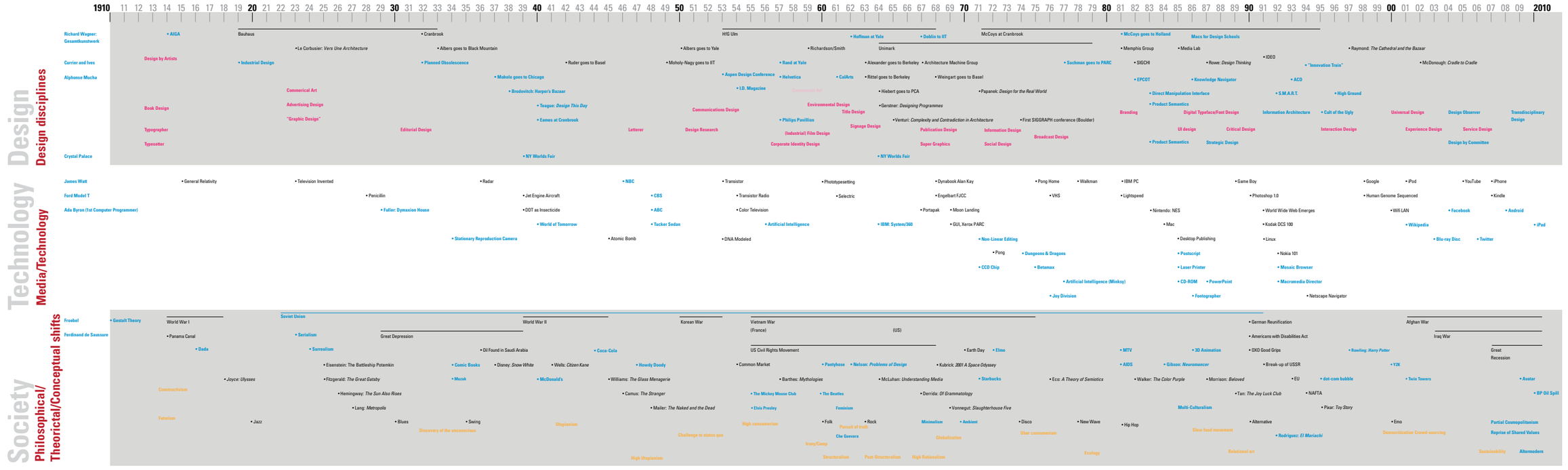
Cybernetics and Systems Design Timeline

This timeline describes major events in the development of cybernetics, operations research, systems analysis, systems engineering, and systems design (compiled in 2002).



Parallel timelines

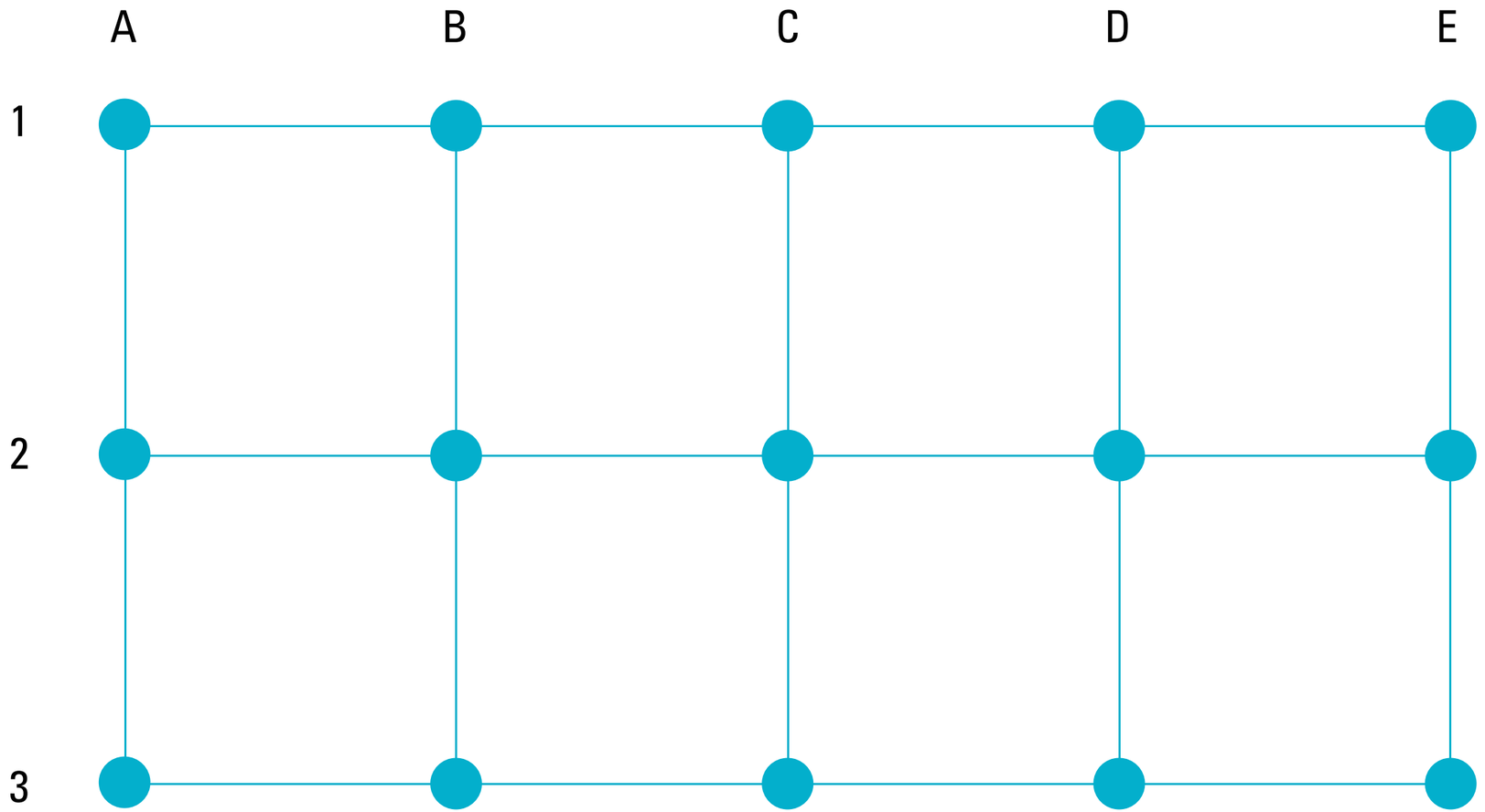
The Past 100 Years



A process may also be represented as a loop, spiral, or helix.

Plane or Matrices

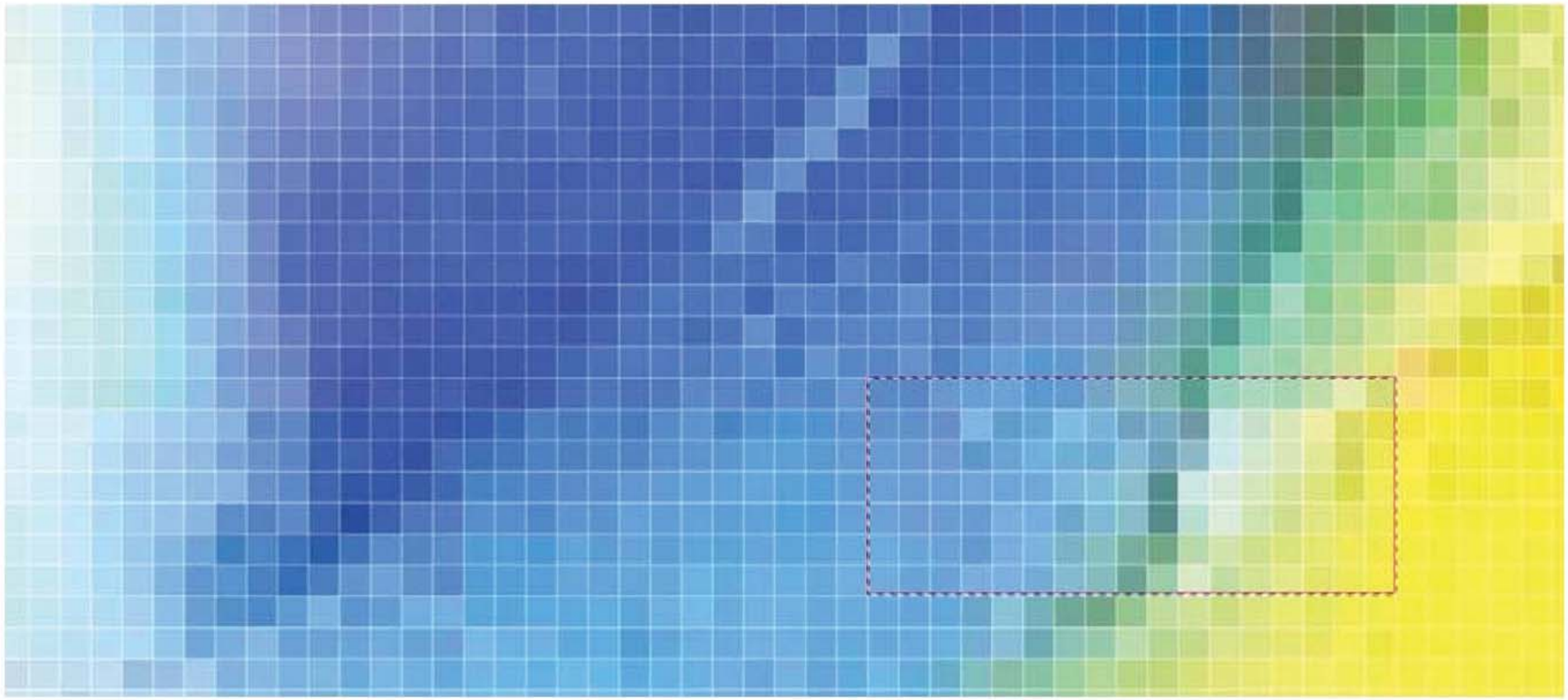
Matrix — also table or “flat file”



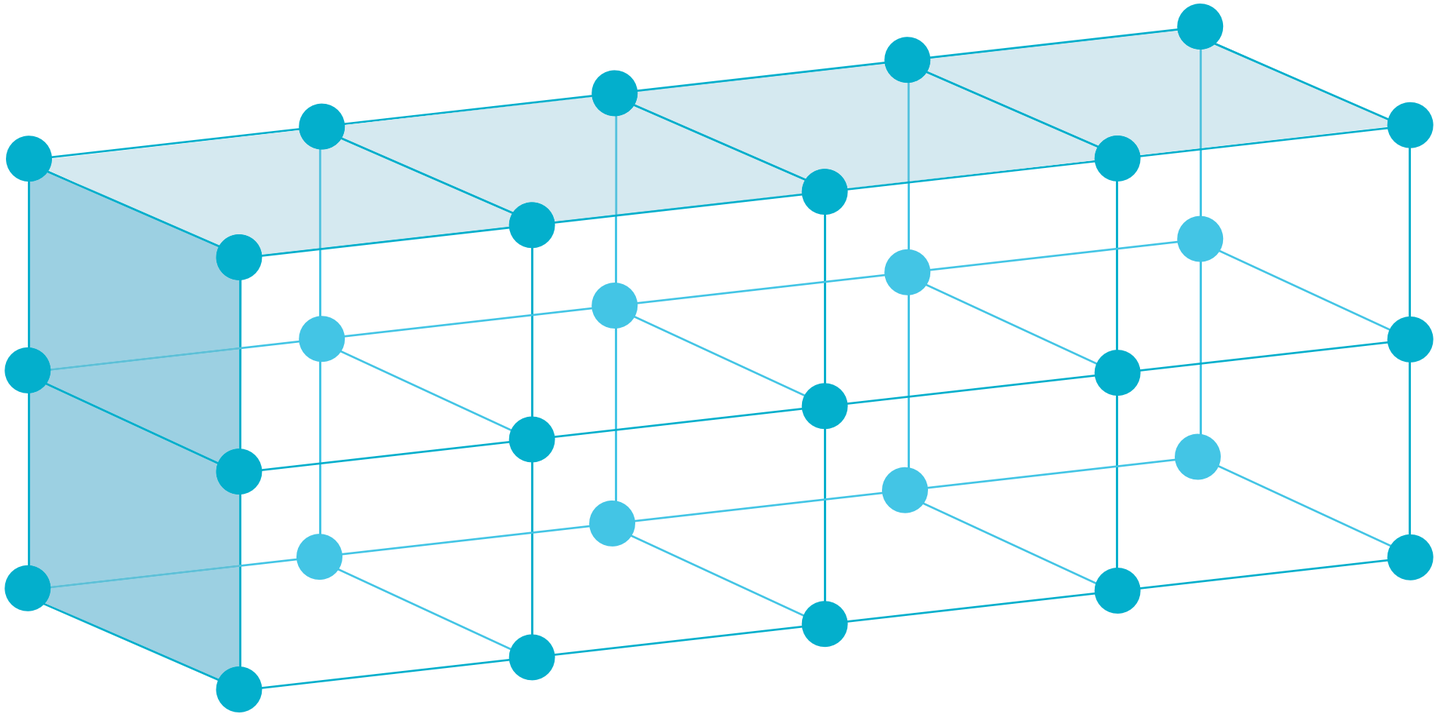
A spreadsheet is a classic matrix structure: rows and columns.

	A	B	C	D
1		**FY 10**	**FY 11**	
2	Jan	1	2	
3	Feb	3	4	
4	March	5	6	
5	April	7	8	
6				
7	**Totals**	16	=SUM(C2:C5)	
8				
9				
10				

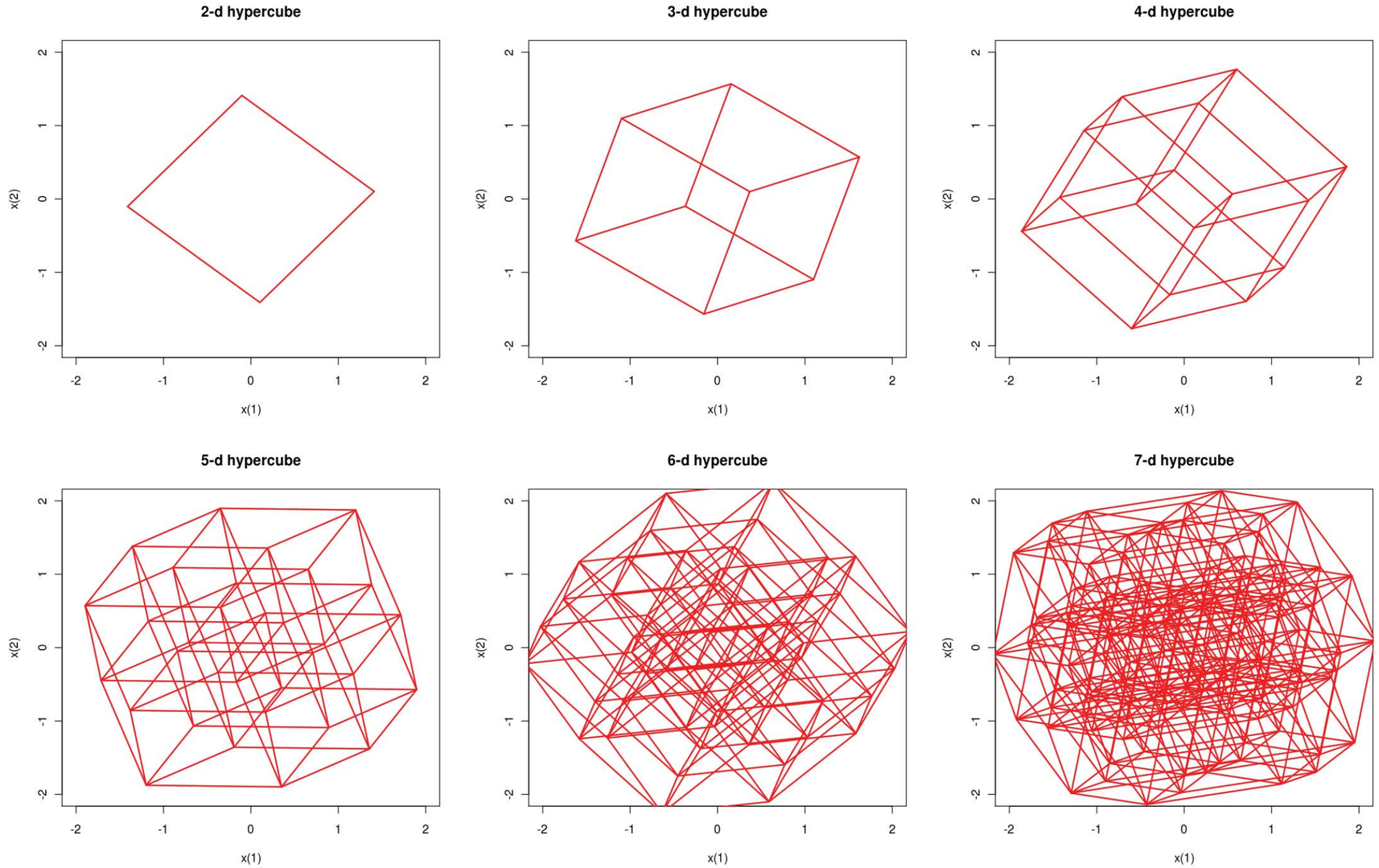
A digital image also has a matrix structure; the file header defines the number of rows + columns.



A matrix may be 3D.



Or 4D or more dimensions.

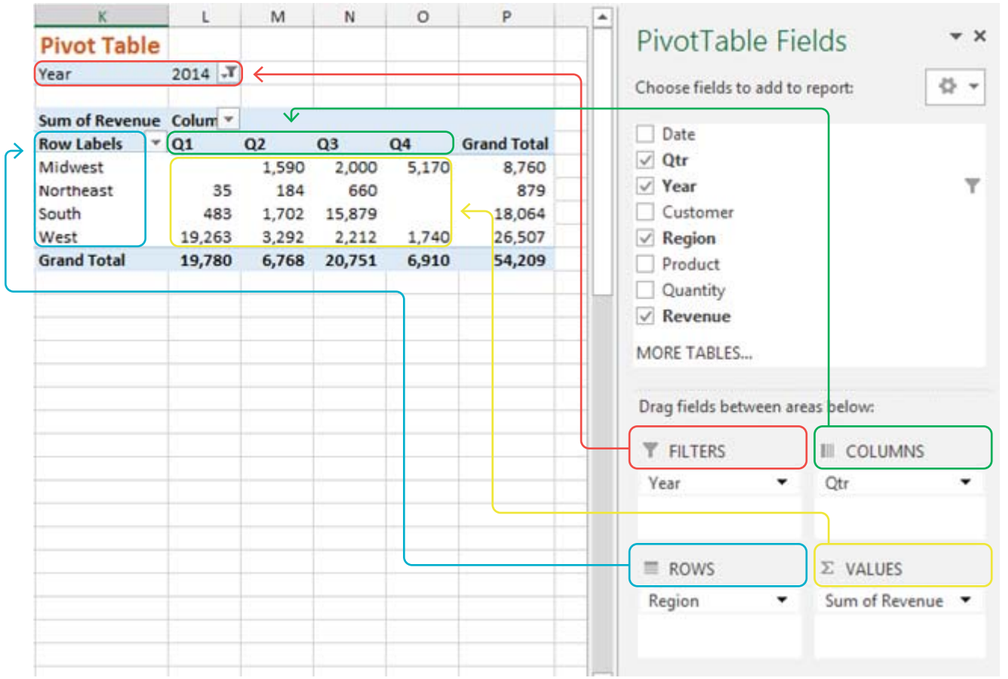


E.g., A well organized stockroom is a “walk-in matrix”.

Pivot tables

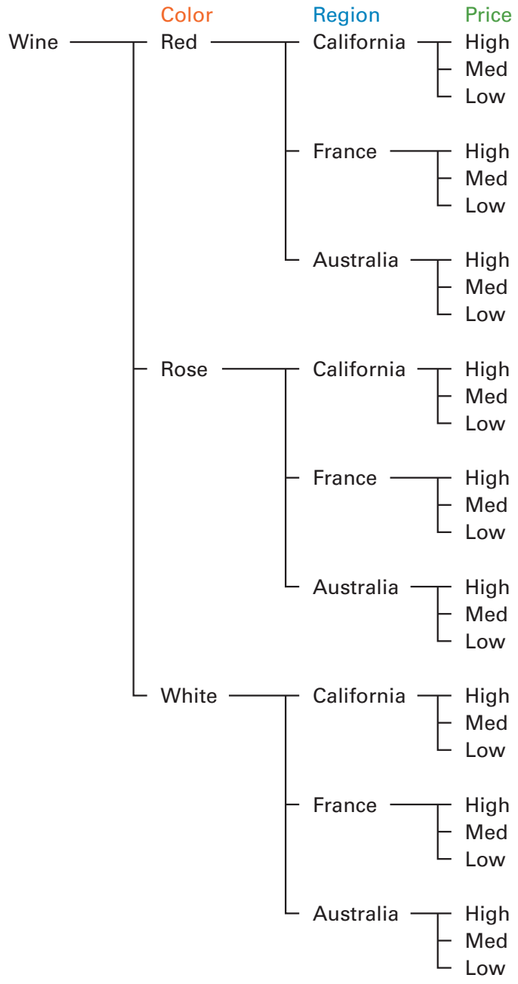
A tool that allows you to summarize and explore large sets of data into a meaningful report.

	A	B	C	D	E	F	G	H
1	Source Data for Pivot Table							
2	Date	Qtr	Year	Customer	Region	Product	Quantity	Revenue
3	01/05/13	Q1	2013	Customer 4	West	Product 9	15	270
4	03/12/13	Q1	2013	Customer 1	Midwest	Product 3	20	200
5	03/14/13	Q1	2013	Customer 6	West	Product 8	25	1,150
6	03/27/13	Q1	2013	Customer 3	West	Product 1	14	100
7	04/14/13	Q2	2013	Customer 6	Northeast	Product 7	16	400
8	04/16/13	Q2	2013	Customer 7	Midwest	Product 5	40	510
9	04/25/13	Q2	2013	Customer 6	South	Product 3	20	70
10	04/28/13	Q2	2013	Customer 6	Midwest	Product 6	10	92
11	07/03/13	Q3	2013	Customer 2	West	Product 7	29	350
12	07/06/13	Q3	2013	Customer 6	Midwest	Product 7	10	128

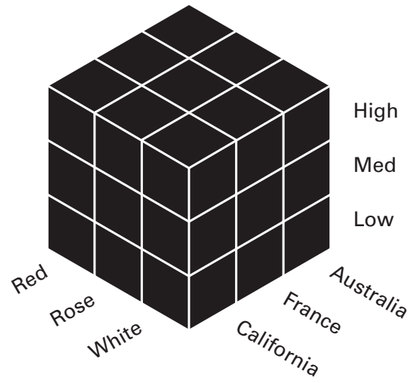


A matrix may be represented as a tree (and vice versa), e.g., “all wine”

Tree



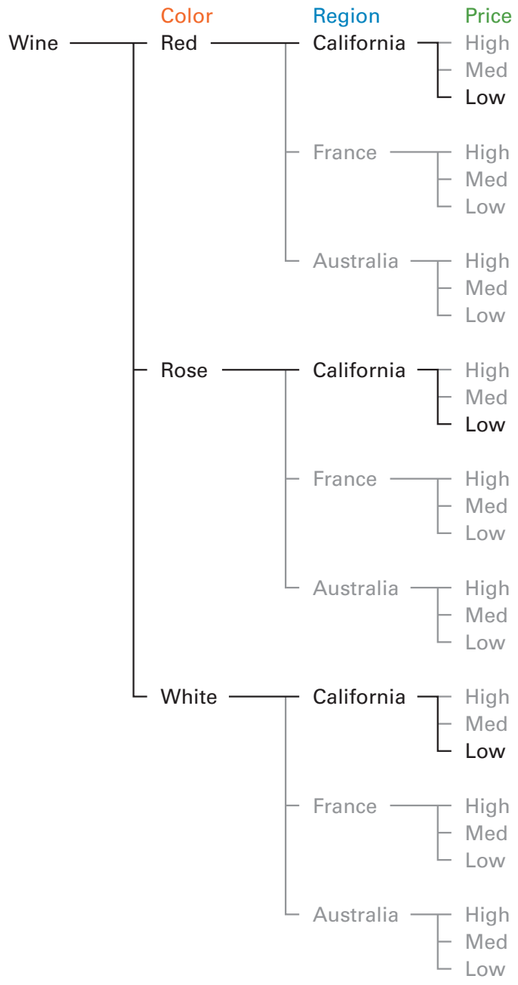
Cube



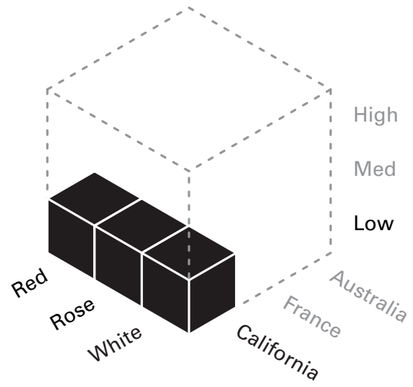
Interface

Filtering narrows selection, e.g., “California, low cost”

Tree



Cube



Interface

Criteria:

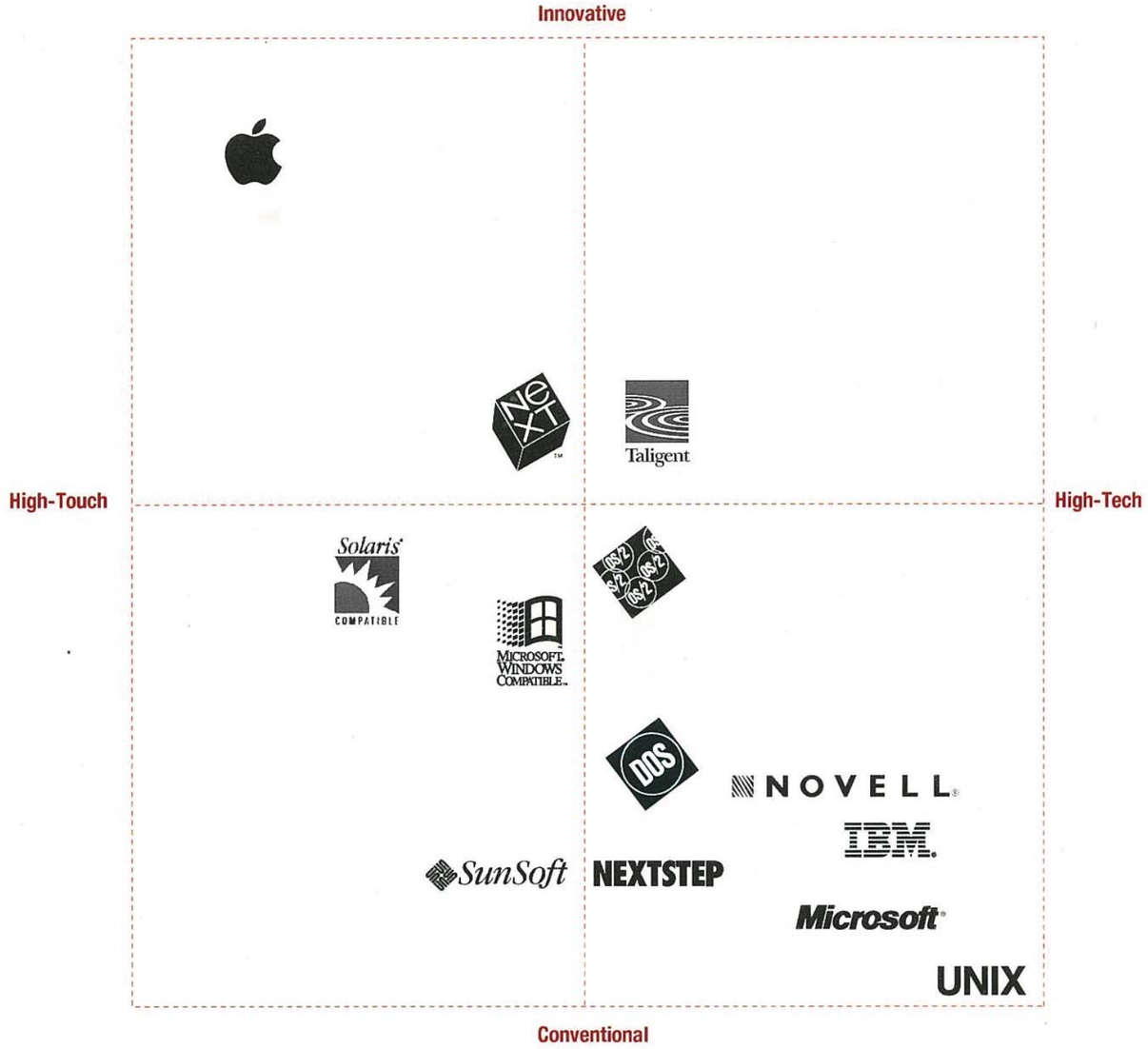
☑ Red	☑ California	☐ High
☑ Rose	☐ France	☐ Med
☑ White	☐ Australia	☑ Low

Result:

3 Bottles
1) La Crema Chardonnay
2) Bonny Doon “Vin Gris de Cigare”
3) Beaulieu Vineyards Cabernet Sauvignon

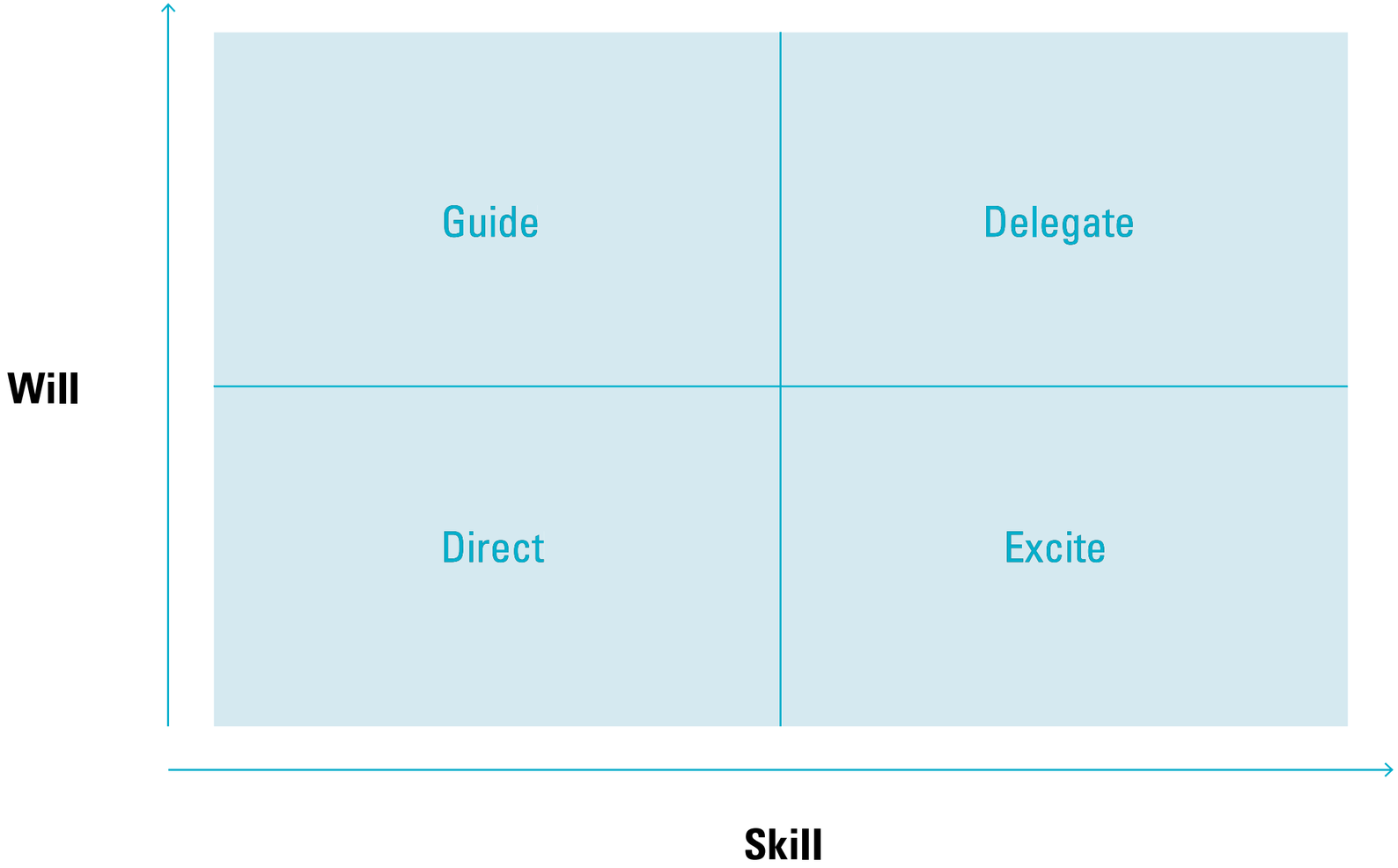
2 x 2s are a type of matrix

Perceptual Mapping / Position Map

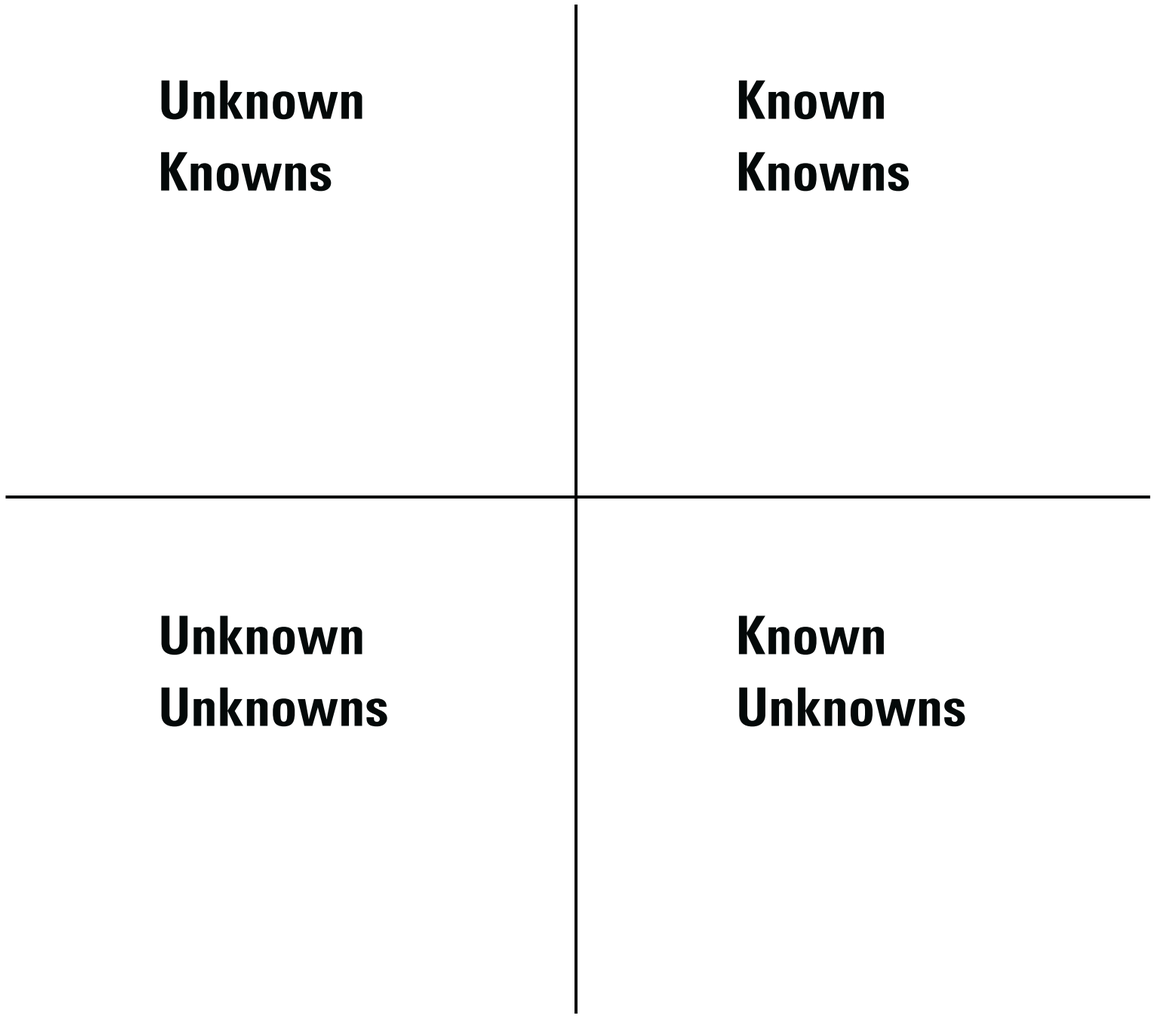


Willingness vs Ability — Managerial Responses

Skill vs Will — Managerial Responses



Known vs Unknown



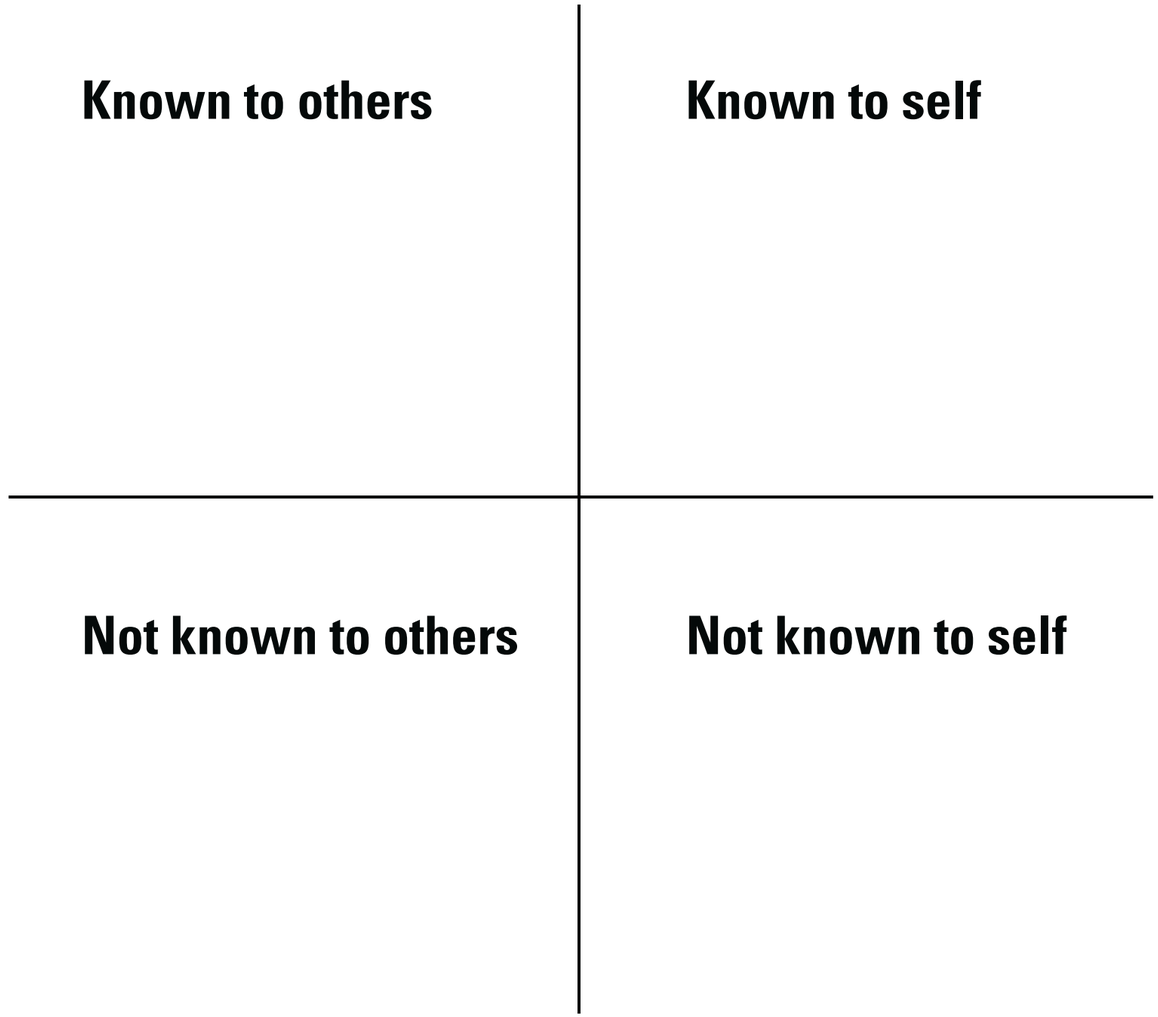
Data thrown off by operations, but not used

What we are already measuring

Correlations that might be discovered

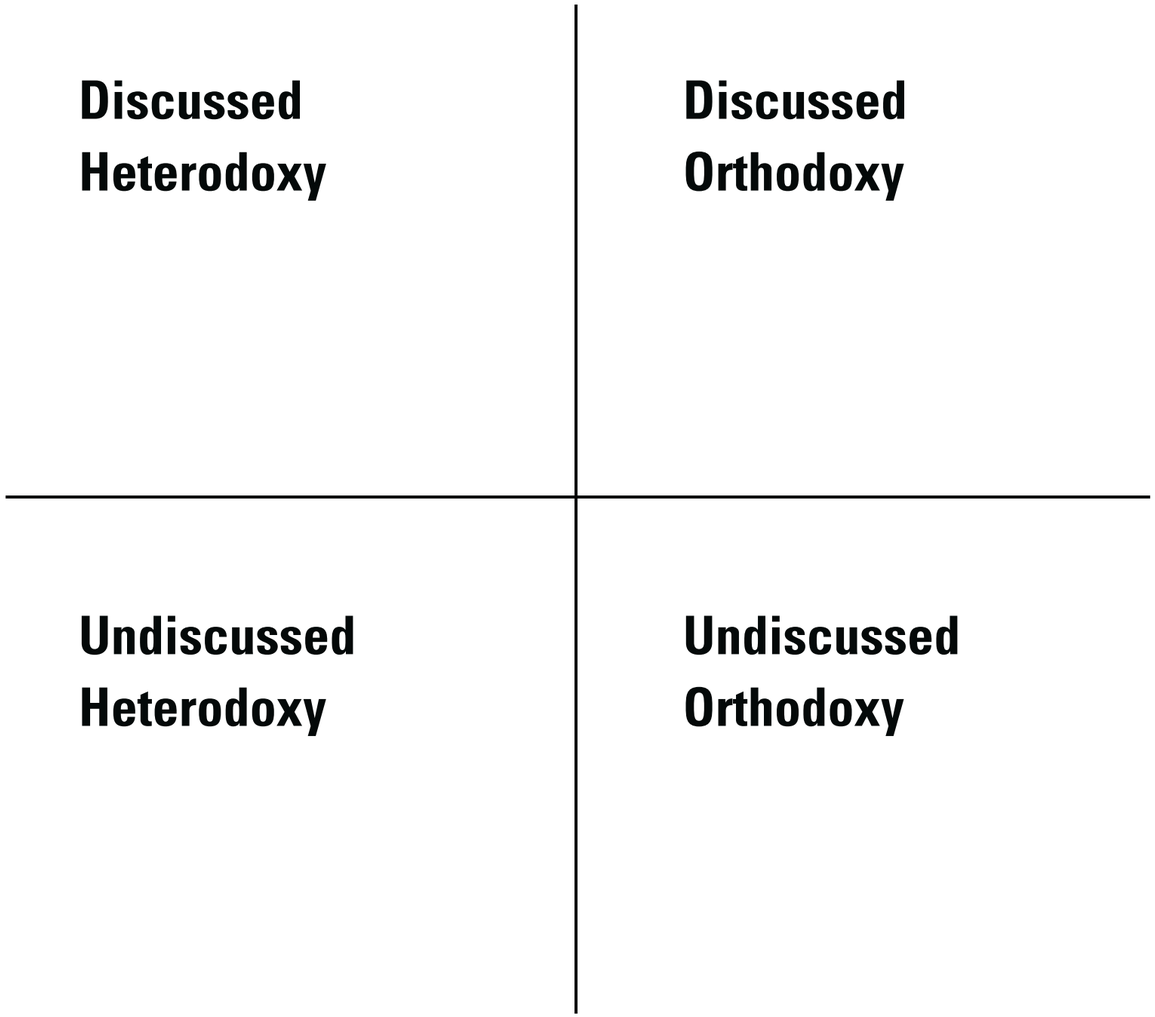
What we are planning to measure (or is not worth the cost)

Johari window, Joseph Luft & Harrington Ingham, 1955



Doxa, Pierre Bourdieu, 1972

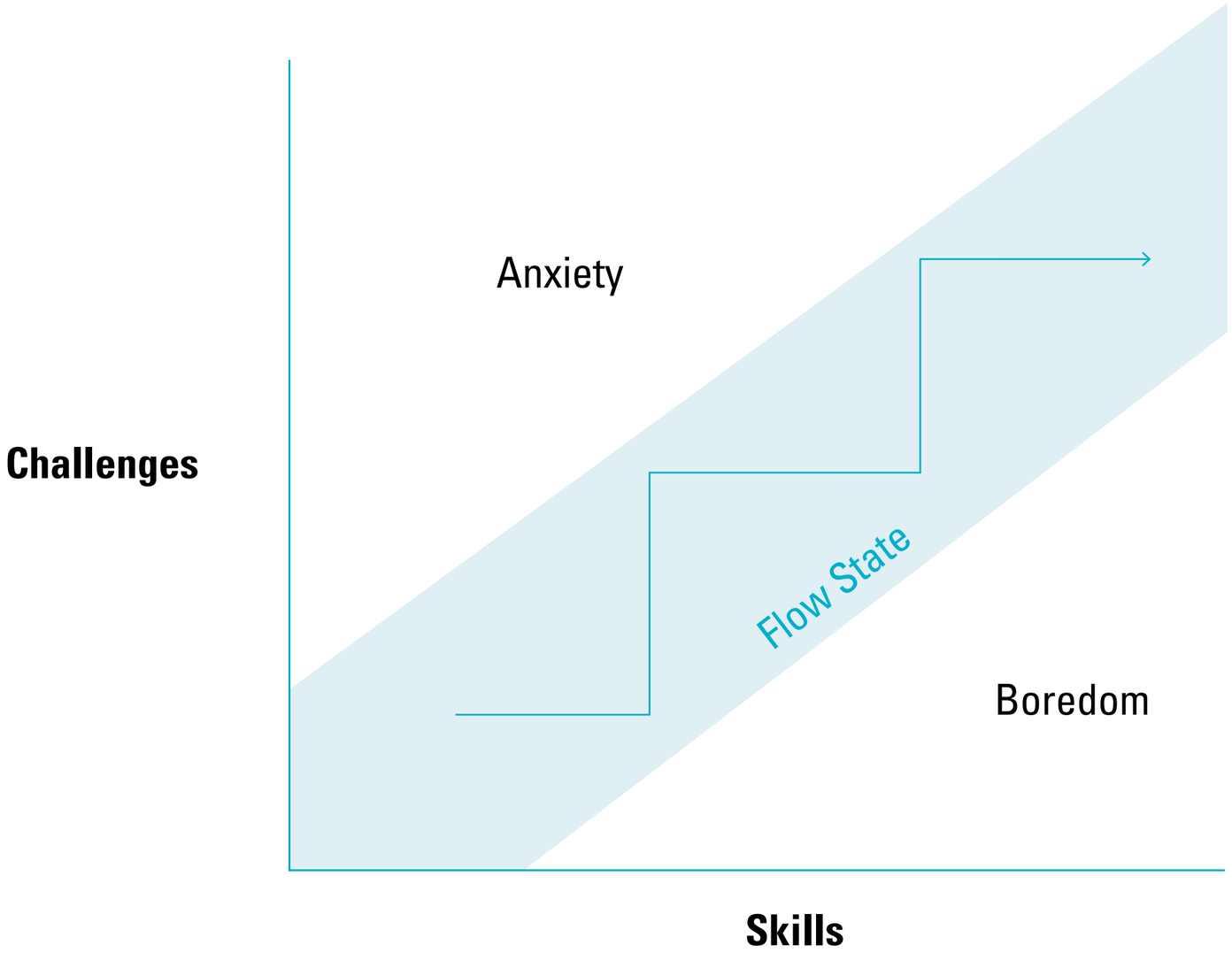
The universe of discourse



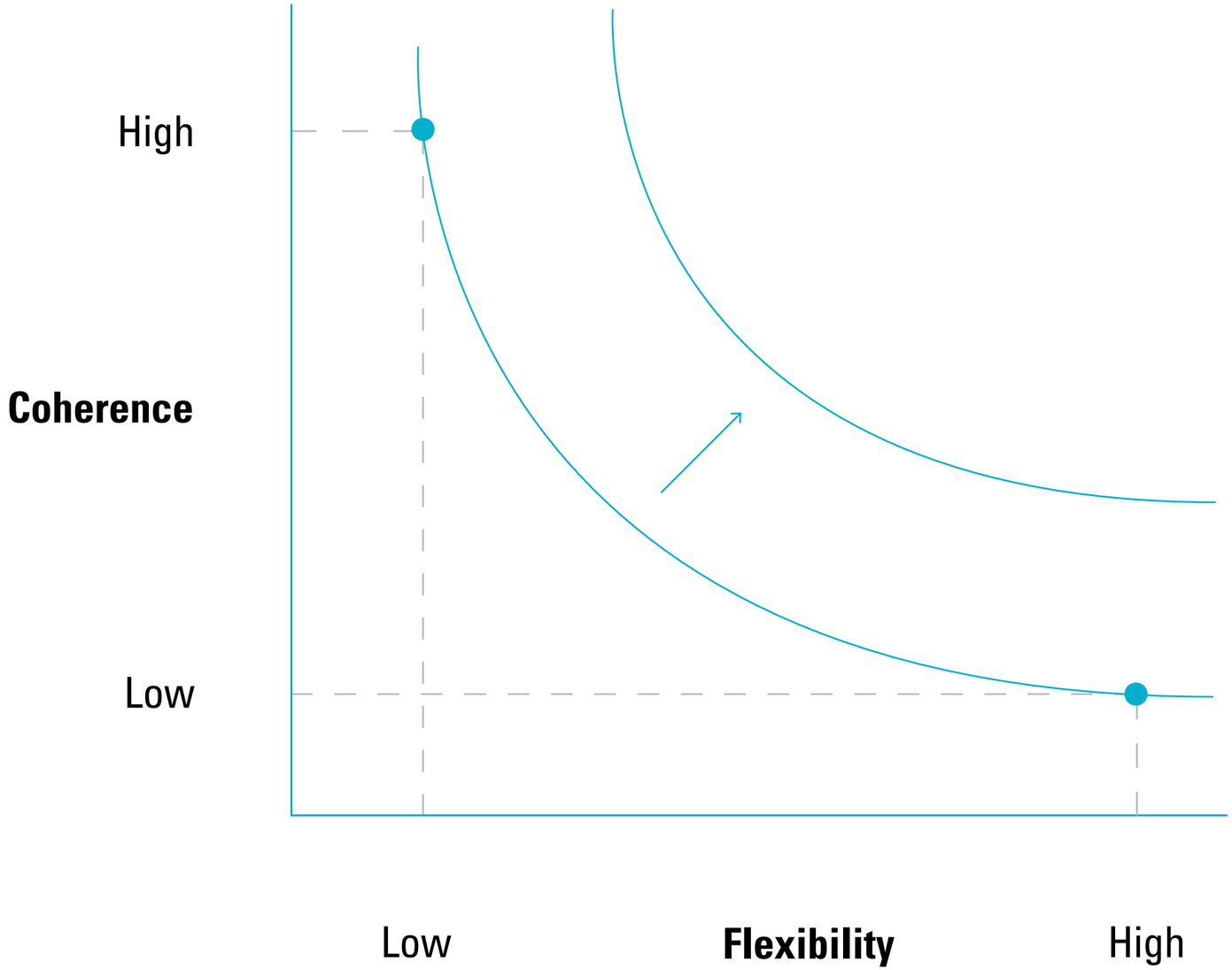
What we see in the press; what's taught in schools

The universe of the undiscovered

Flow



Pliant Systems



Era analysis tables are another type of matrix

Design practice is moving from a focus on objects to a focus on systems.

	1900 - 2000	1995 - now
Values	**Seek simplicity**	**Embrace complexity**
Designer’s role	**Expert/Deciding**	**Collaborator/Facilitating**
Construction	**Direct**	**Mediated**
Stopping condition	**Almost perfect**	**Good enough for now**
Result	**More deterministic**	**Less predictable**
End state	**Completed**	**Adapting, growing**

Product era analysis

Dubberly, Cain, Forlizzi, & Pangaro, 2019

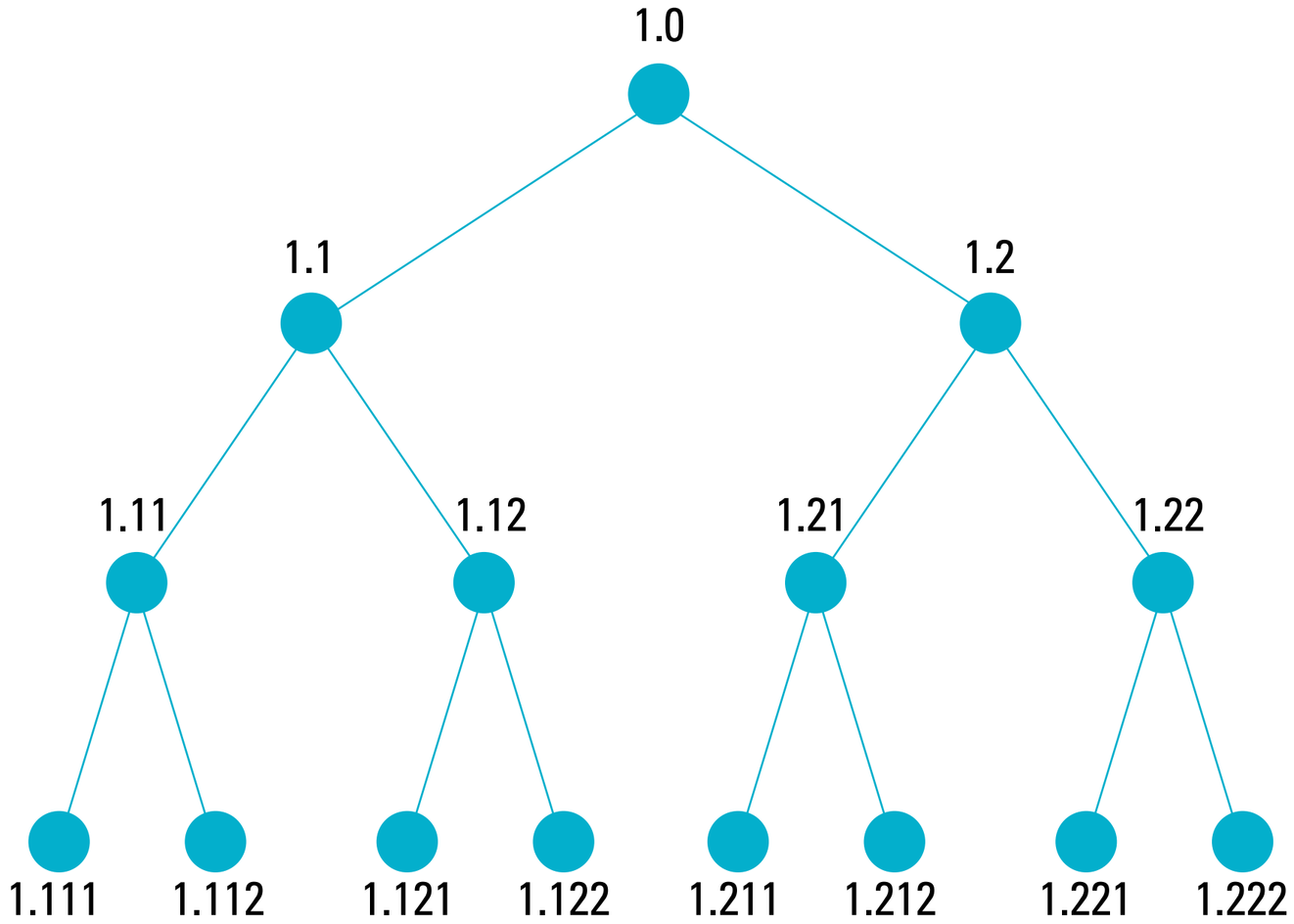
	Hand-crafted Objects	Mass-produced Products	Product-service Ecologies
Scale	Small (one-at-a-time)	Huge (large batches)	Huge (world-wide)
Timeframe	Bounded	Bounded	Ongoing
Complexity	Limited	Greater	Greater still
Outcomes	In the maker's control	Calculated & optimized	Emergent
Objects	Made by hand	Made by machine	Embedded in service systems
Associations	Maker knows user	Anonymous transaction	Surveillance "relationship"
Values	Waste not / want not	Solve / specify	Adapt / test

Product era analysis (cont.)
Dubberly, Cain, Forlizzi, & Pangaro, 2019

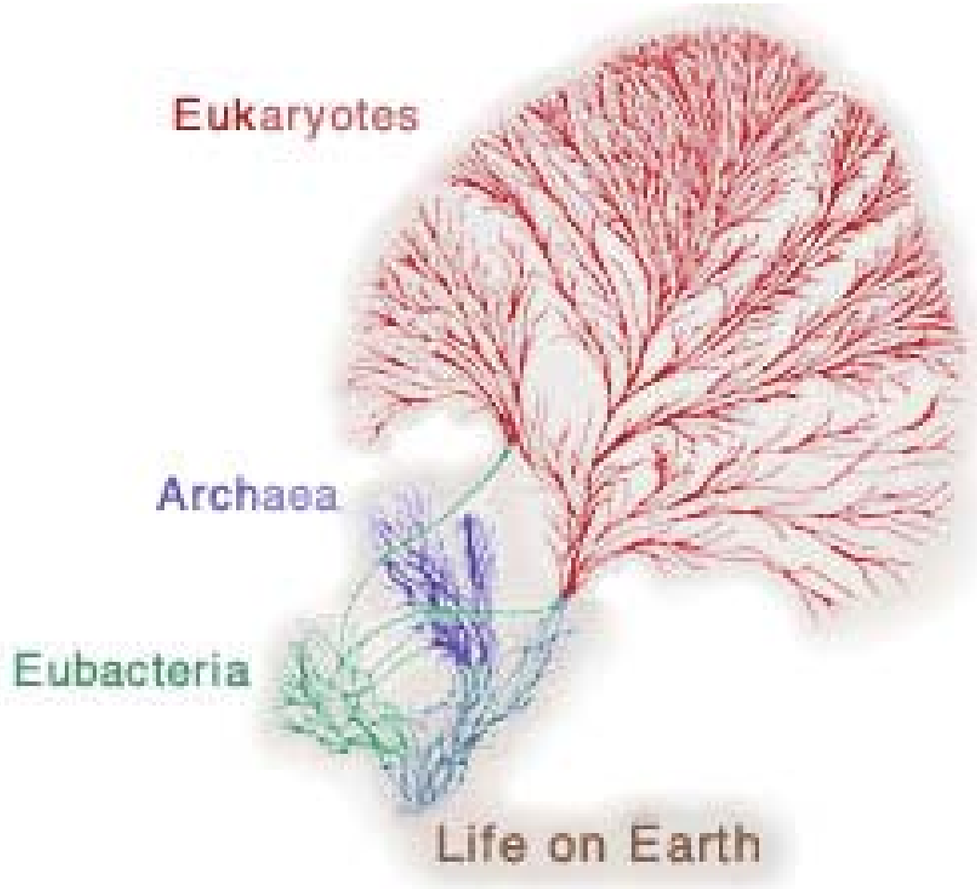
Handcrafted Objects	Mass-produced Products	Product-service Ecologies
Design occurs *during* making, modifications for context.	Customer input is rare; extremely small samples.	A-B testing becomes standard; every action is recorded.
– Often, made-to-measure (bespoke, personalized) – Dumb – Stand-alone	– Mostly, made-in-advance (ready-made to standard sizes) – Dumb – Stand-alone	– Mass manufactured *and* mass customized – Smart & aware – Connected to cloud storage, compute, and services
– Knowledge is embedded *in* the artifact and the maker	– Knowledge is embedded in artifact *and* production process	– Knowledge flows from users and back-and-forth through the system

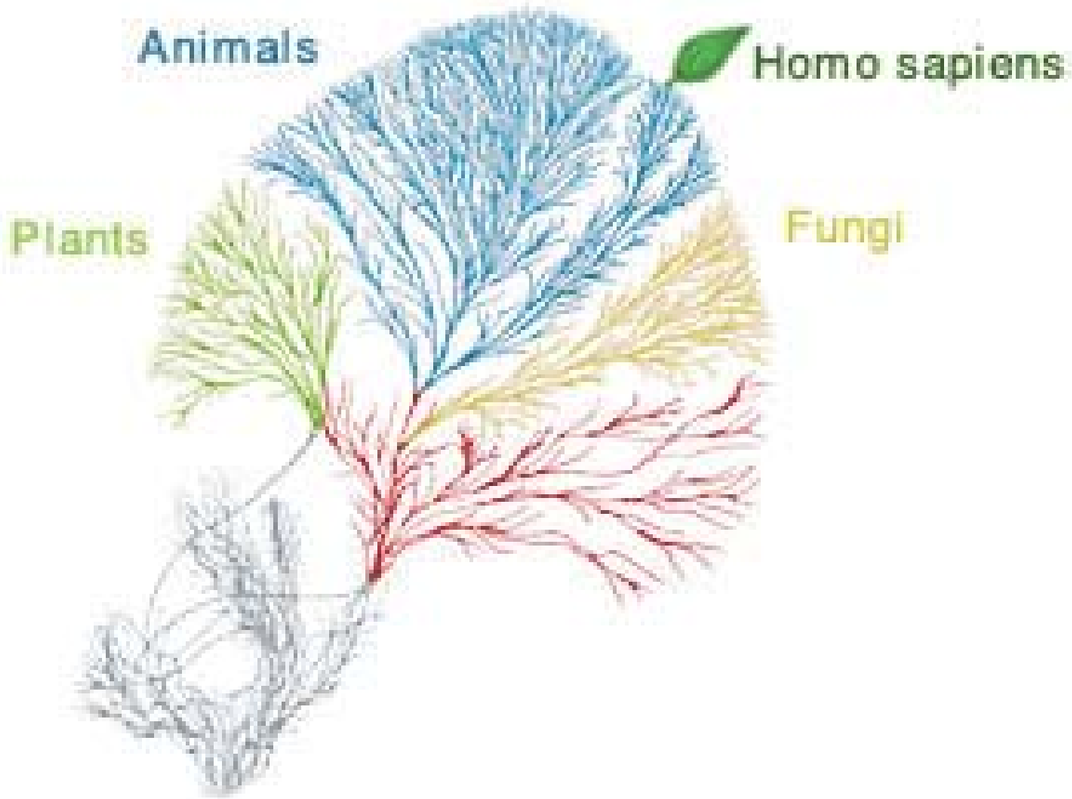
Trees

Tree — also hierarchy, taxonomy

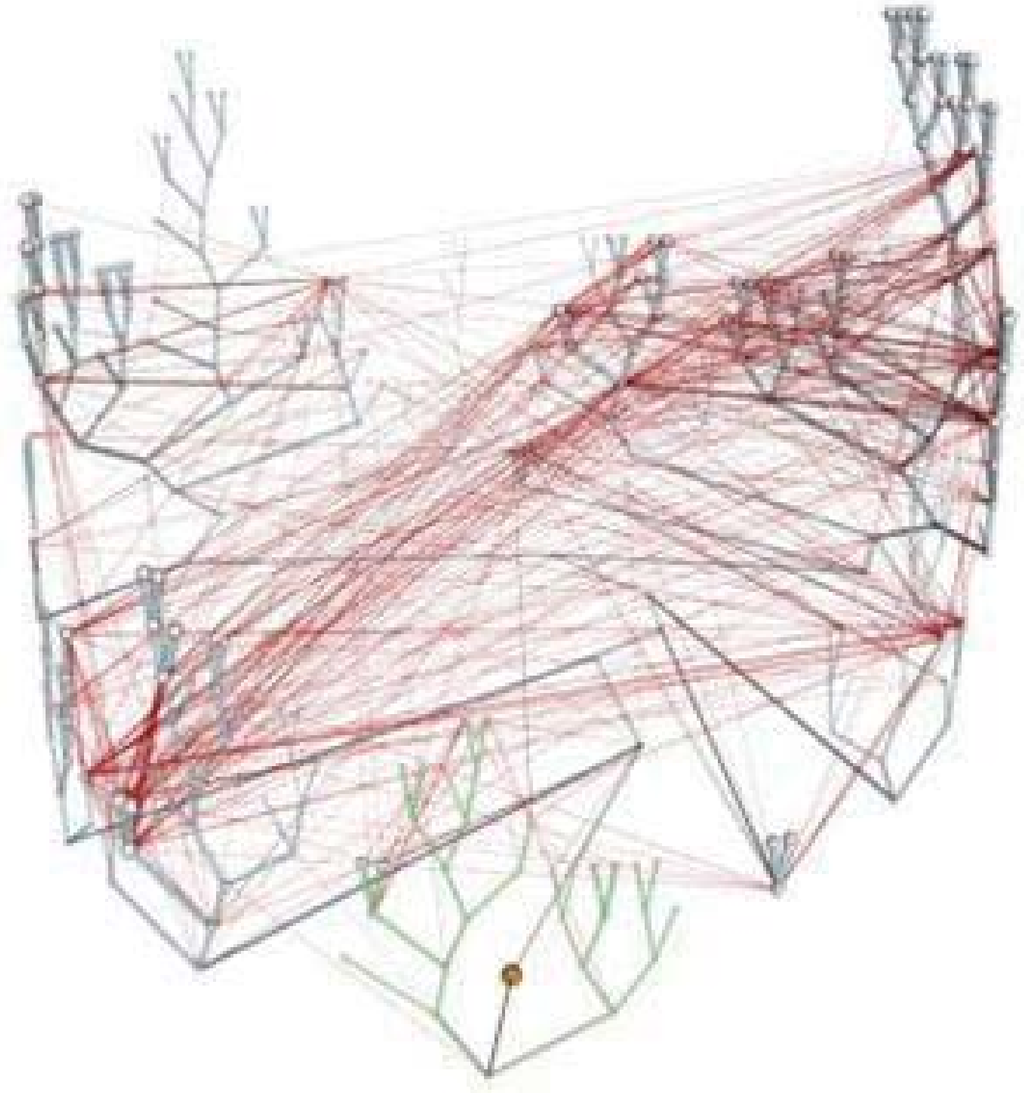


Tree of life

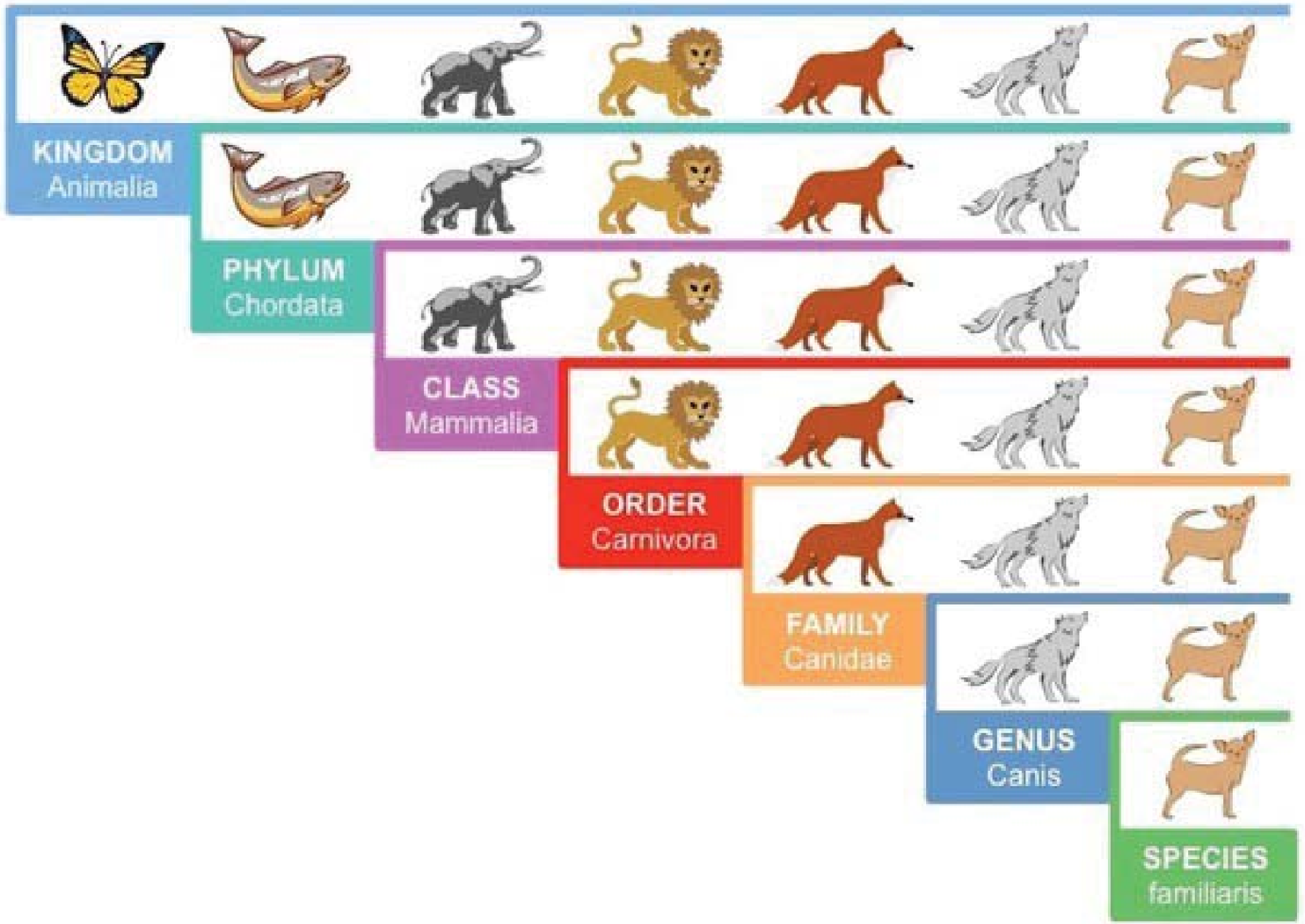

Eukaryotes
Archaea
Eubacteria
Life on Earth


Animals
Homo sapiens
Plants
Fungi

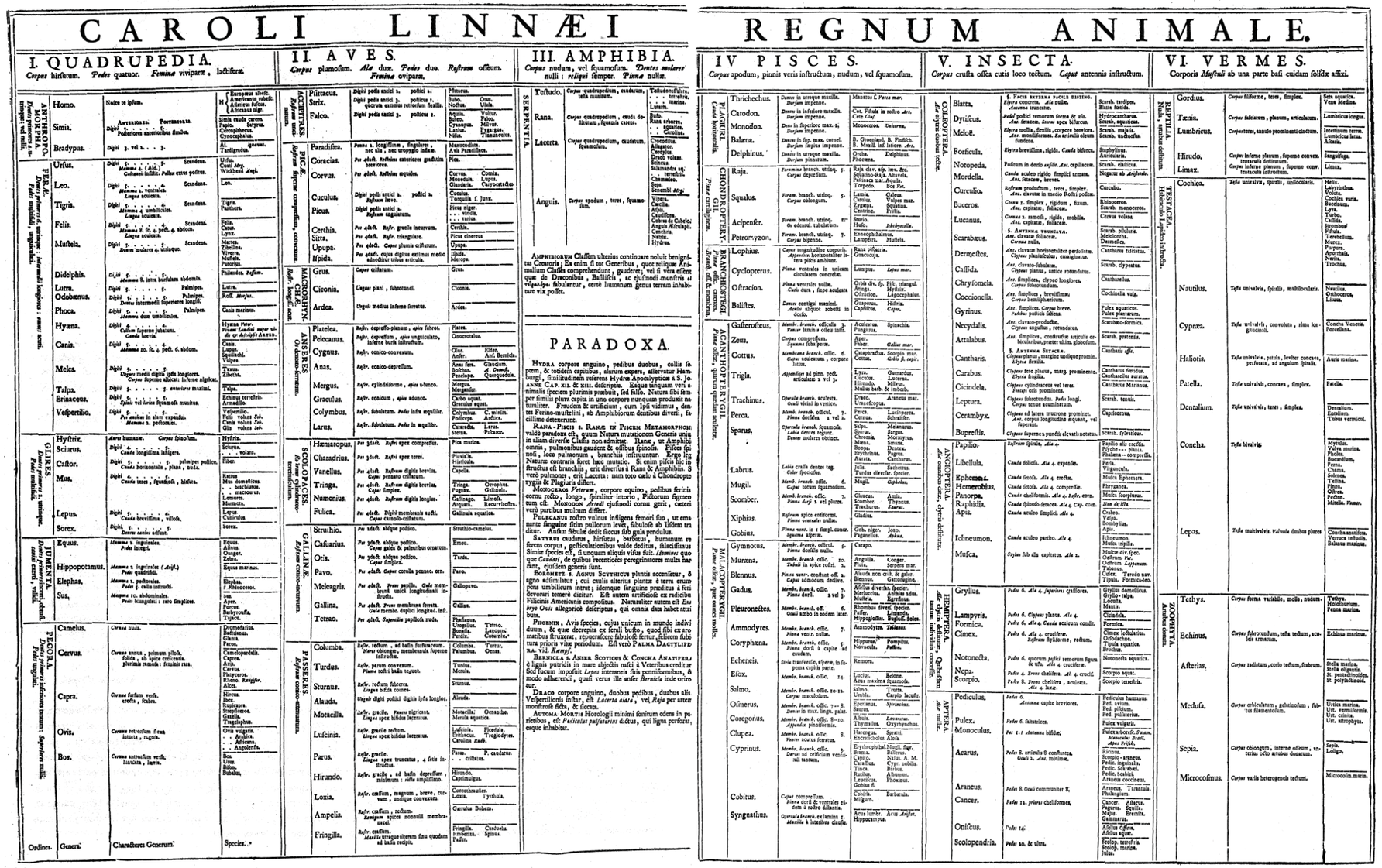
Web of life



Taxonomy


KINGDOM
Animalia
PHYLUM
Chordata
CLASS
Mammalia
ORDER
Carnivora
FAMILY
Canidae
GENUS
Canis
SPECIES
familiaris

Binomial naming, Carl Linnaeus, 1735



CAROLI LINNÆI

REGNUM ANIMALE.

I. QUADRUPEDIA.

II. AVES.

III. AMPHIBIA.

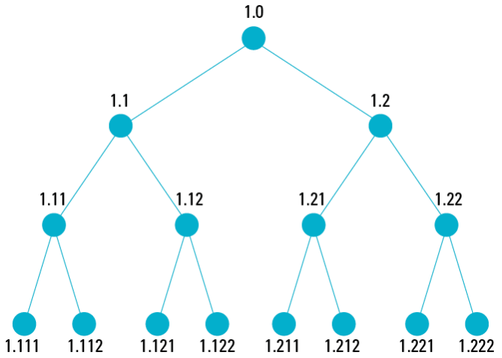
IV PISCES.

V. INSECTA.

VI. VERMES.

PARADOXA.

A tree can be represented as an outline.



1.0 Title

1.1 Section

1.11 SubSection

1.111 Paragraph

1.112 Paragraph

1.12 SubSection

1.121 Paragraph

1.122 Paragraph

1.2 Section

1.21 SubSection

1.211 Paragraph

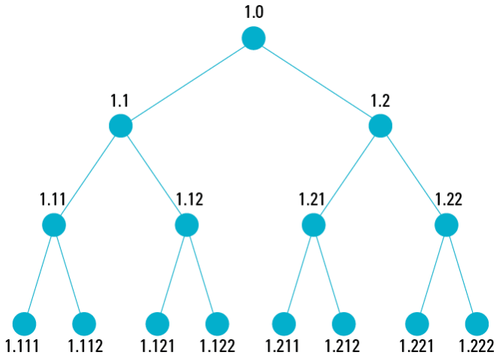
1.212 Paragraph

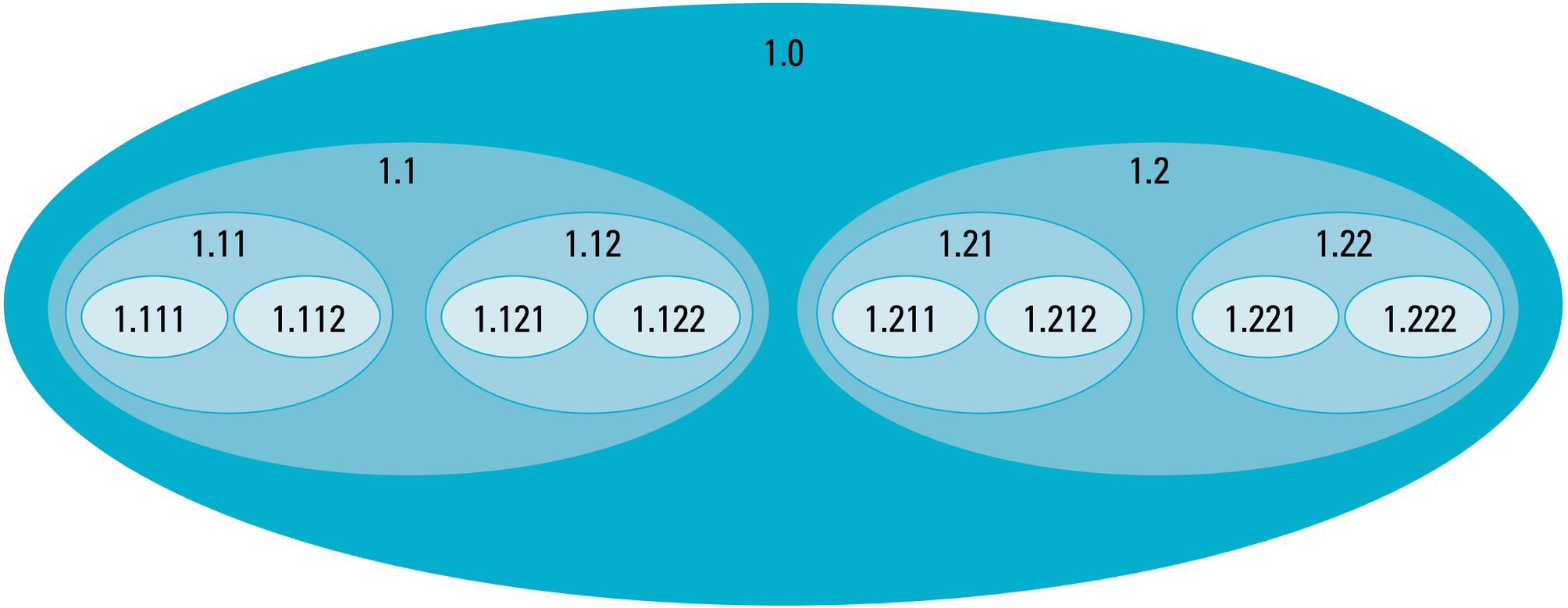
1.22 SubSection

1.221 Paragraph

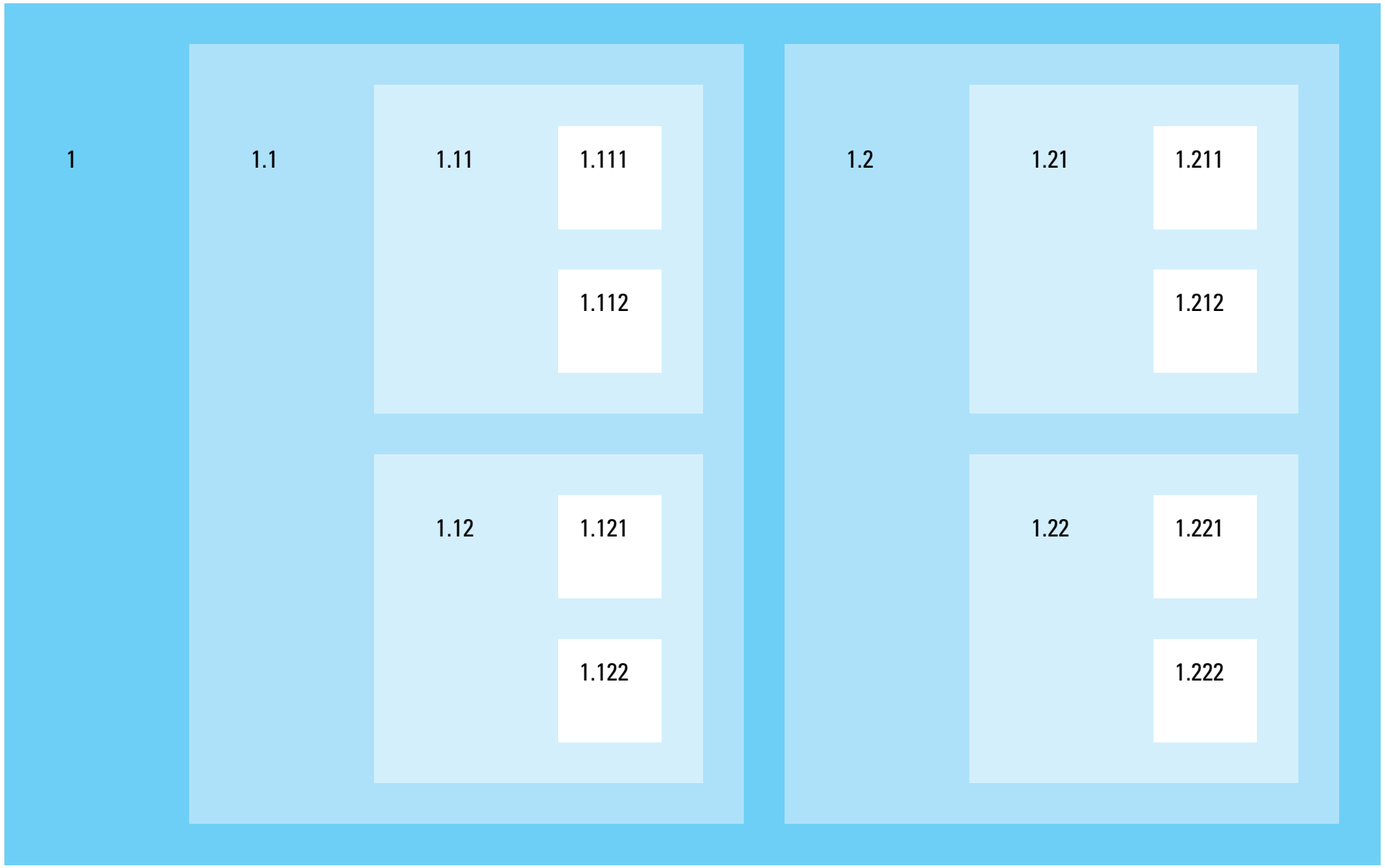
1.222 Paragraph

Trees can also be represented as Venn diagrams.





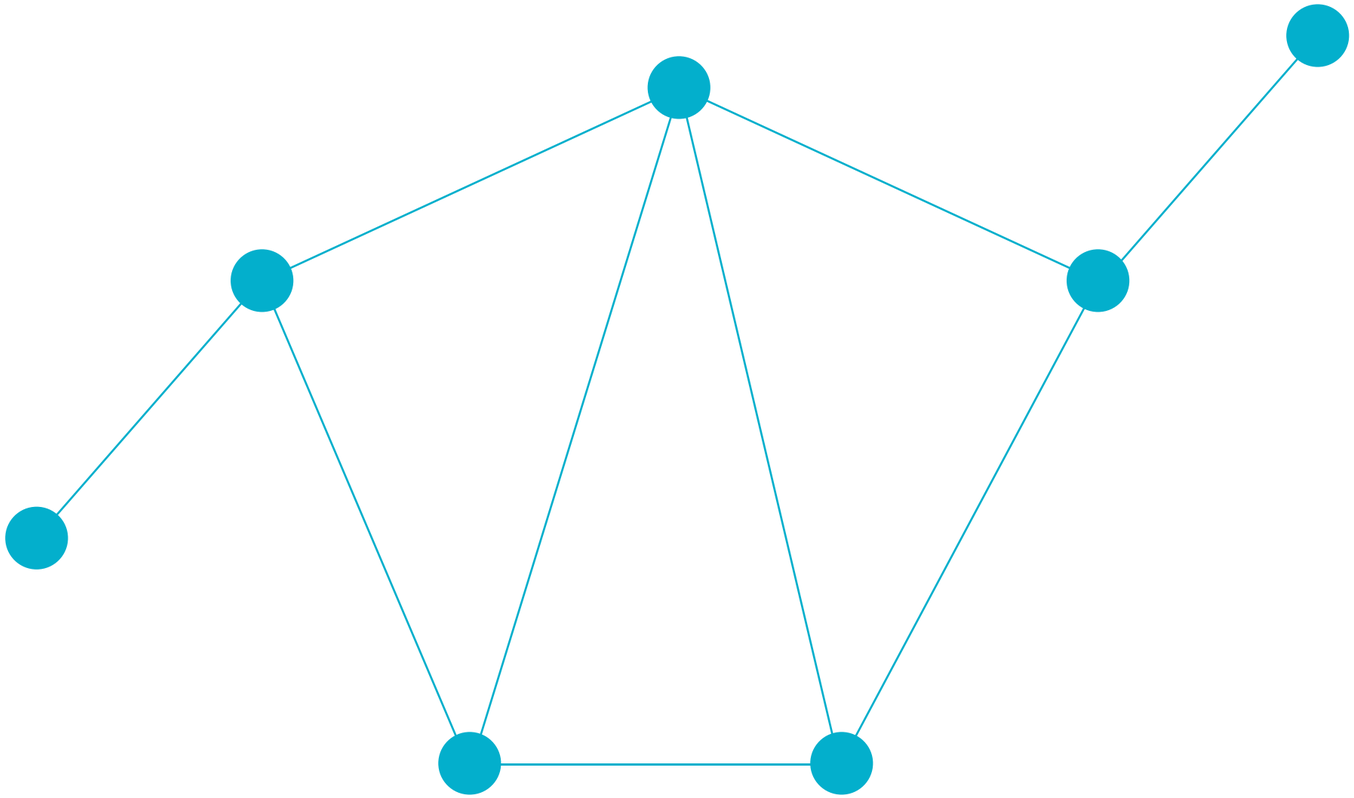
Trees represent containers; shape can vary.



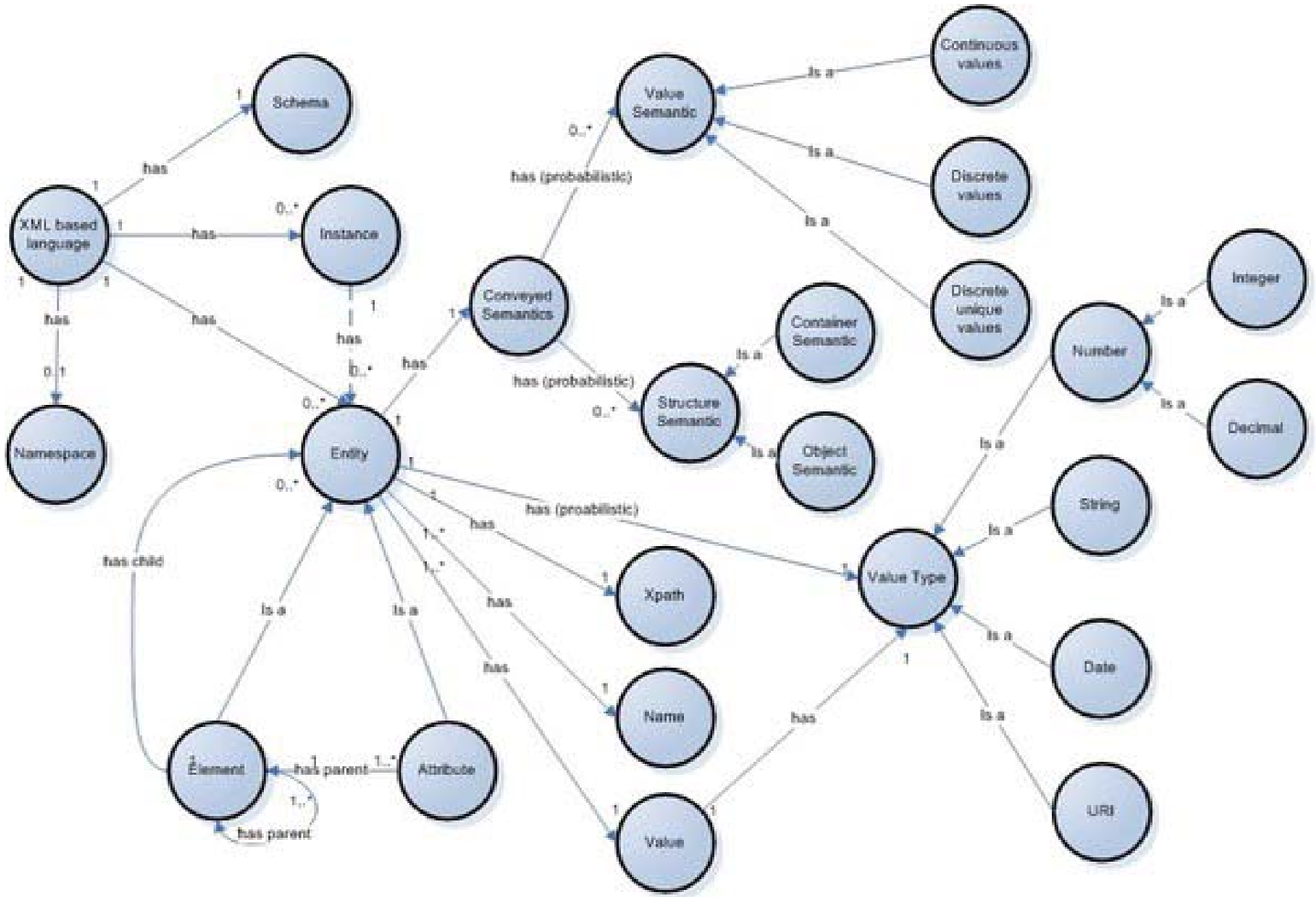
This market map is also a tree.

Webs

Web — also graph, network, ontology

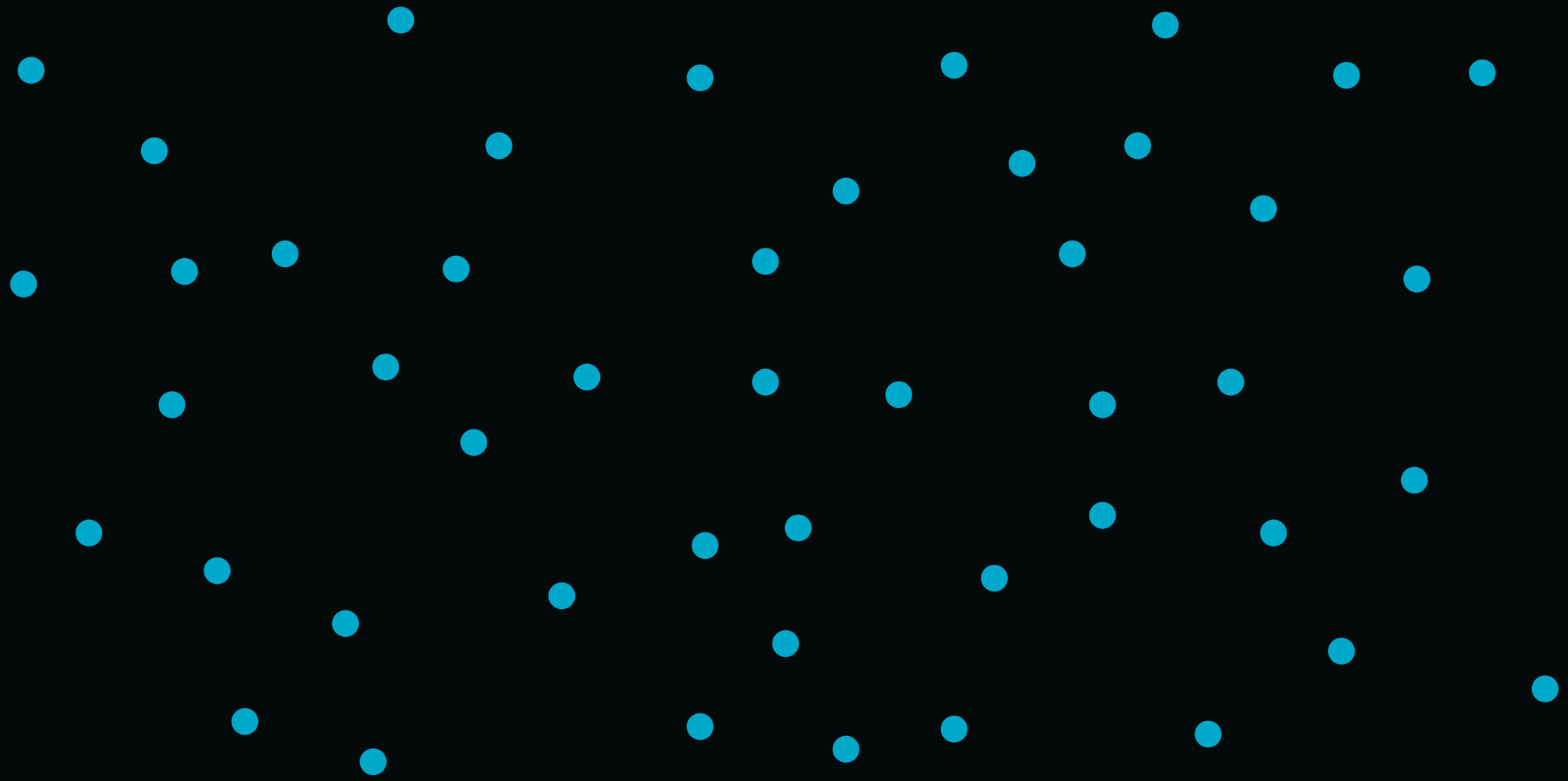


Ontology

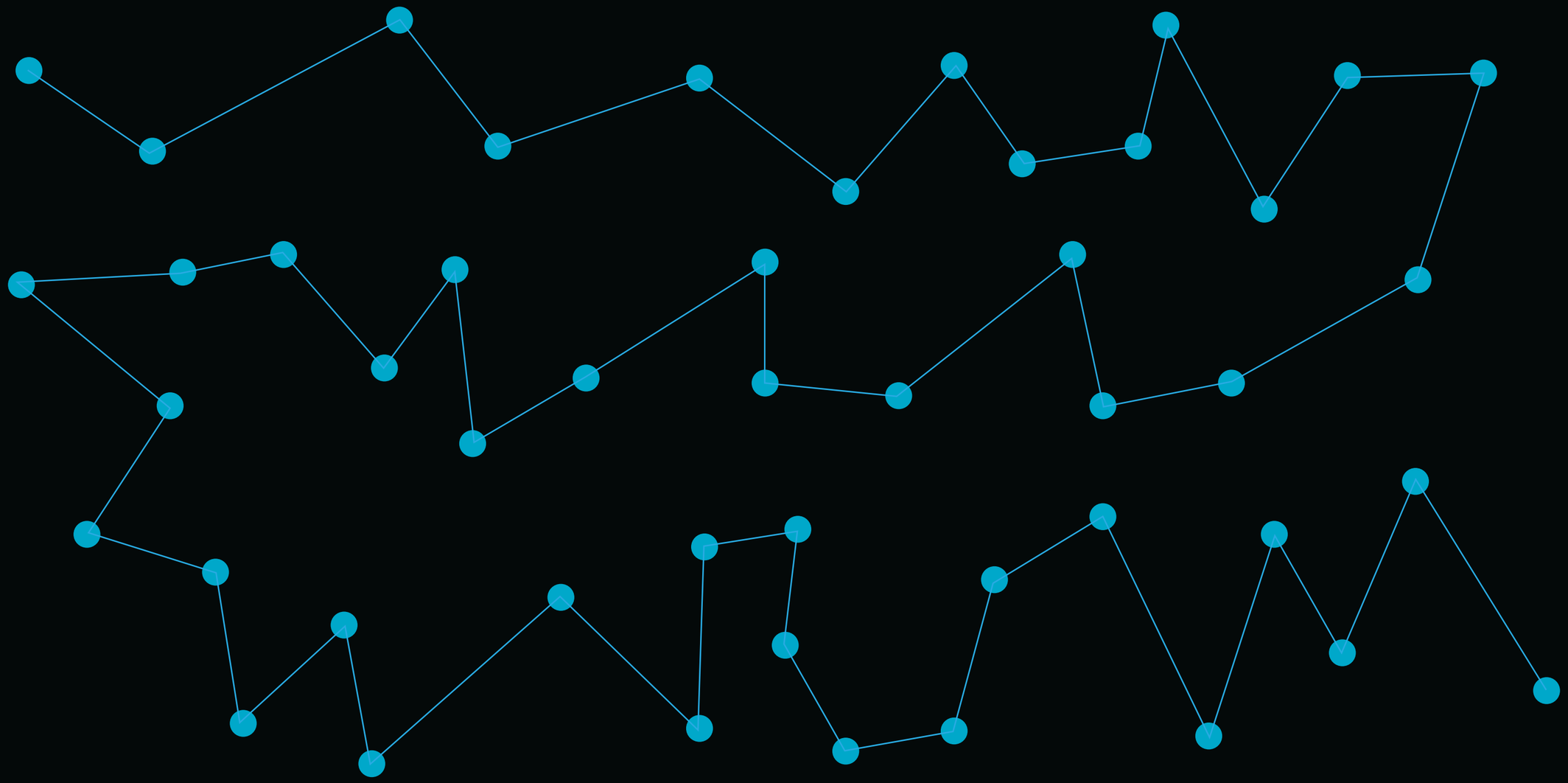

Schema
has
XML based language
has
Instance
has
has
has
Namespace
Entity
has
Conveyed Semantics
has (probabilistic)
Value Semantic
Is a
Continuous values
Is a
Discrete values
Is a
Discrete unique values
has (probabilistic)
Structure Semantic
Is a
Container Semantic
Is a
Object Semantic
has (proabilistic)
Value Type
Number
Is a
Integer
Is a
Decimal
Is a
String
Is a
Date
Is a
URI
has child
Is a
Is a
has
Xpath
has
Name
has
Value
has
Element
has parent
Attribute
has parent

The same set of nodes may be connected to form many different structures.

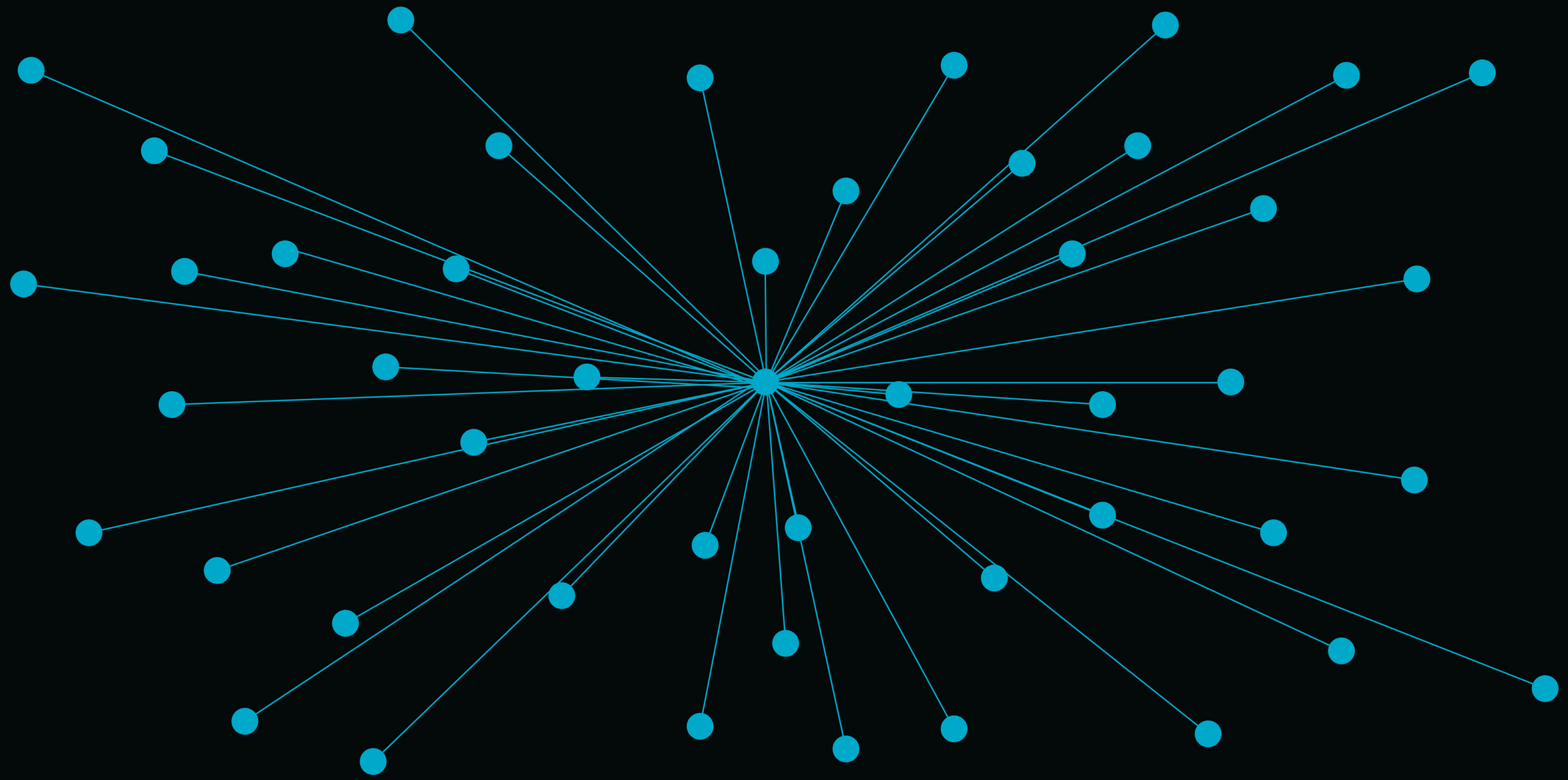
Nodes



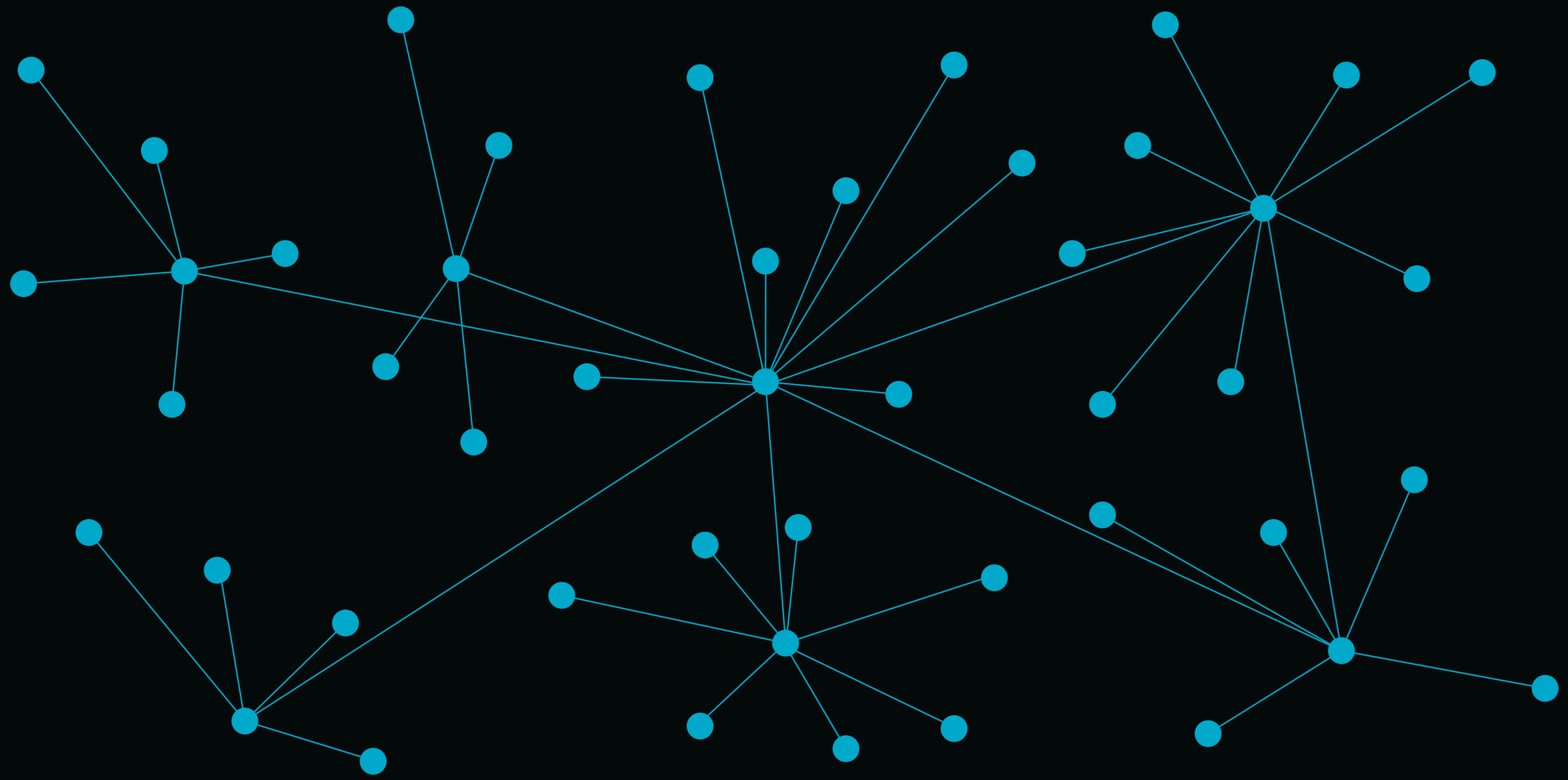
Sequences — “Daisy Chain”



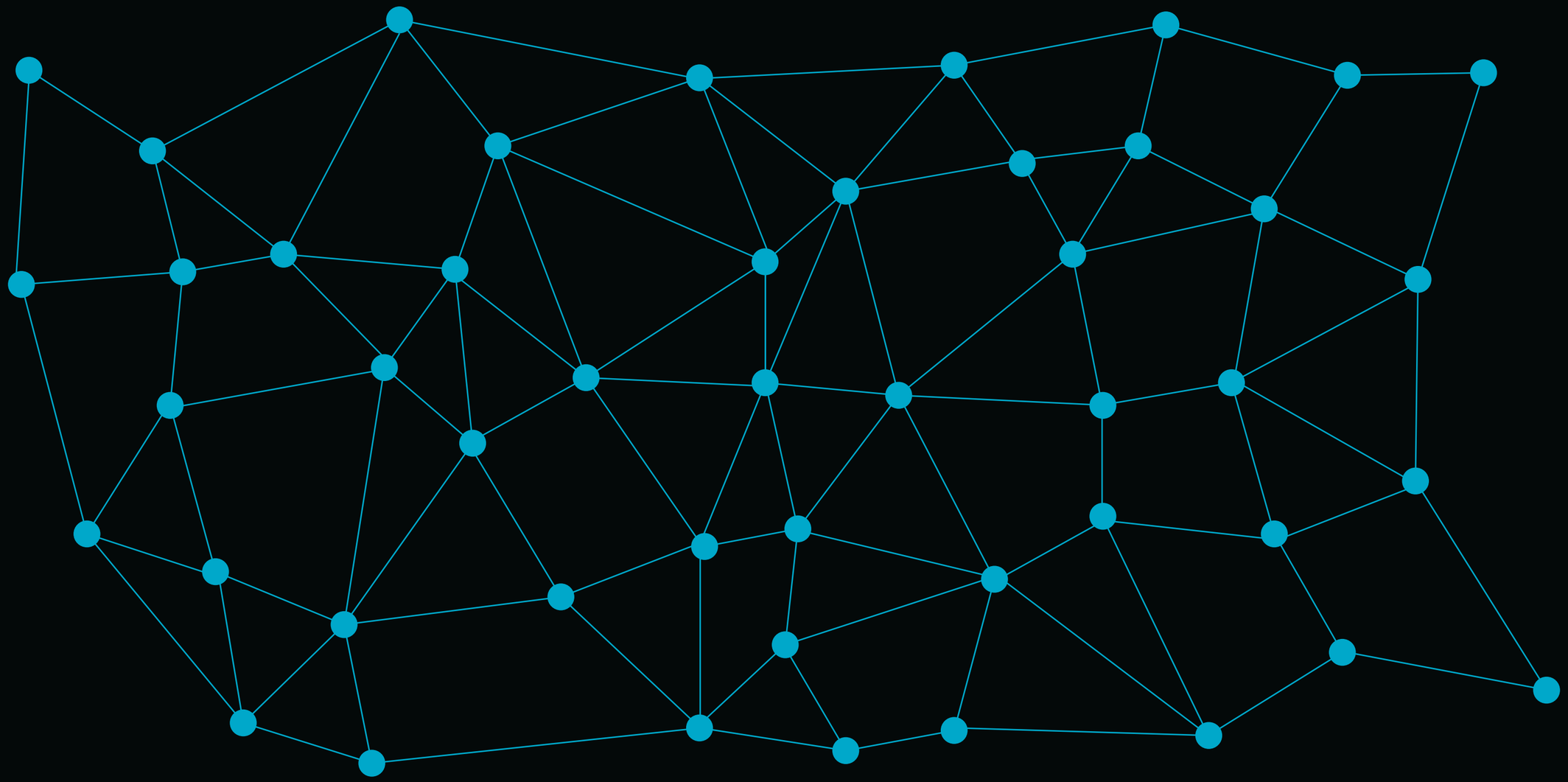
Centralized System



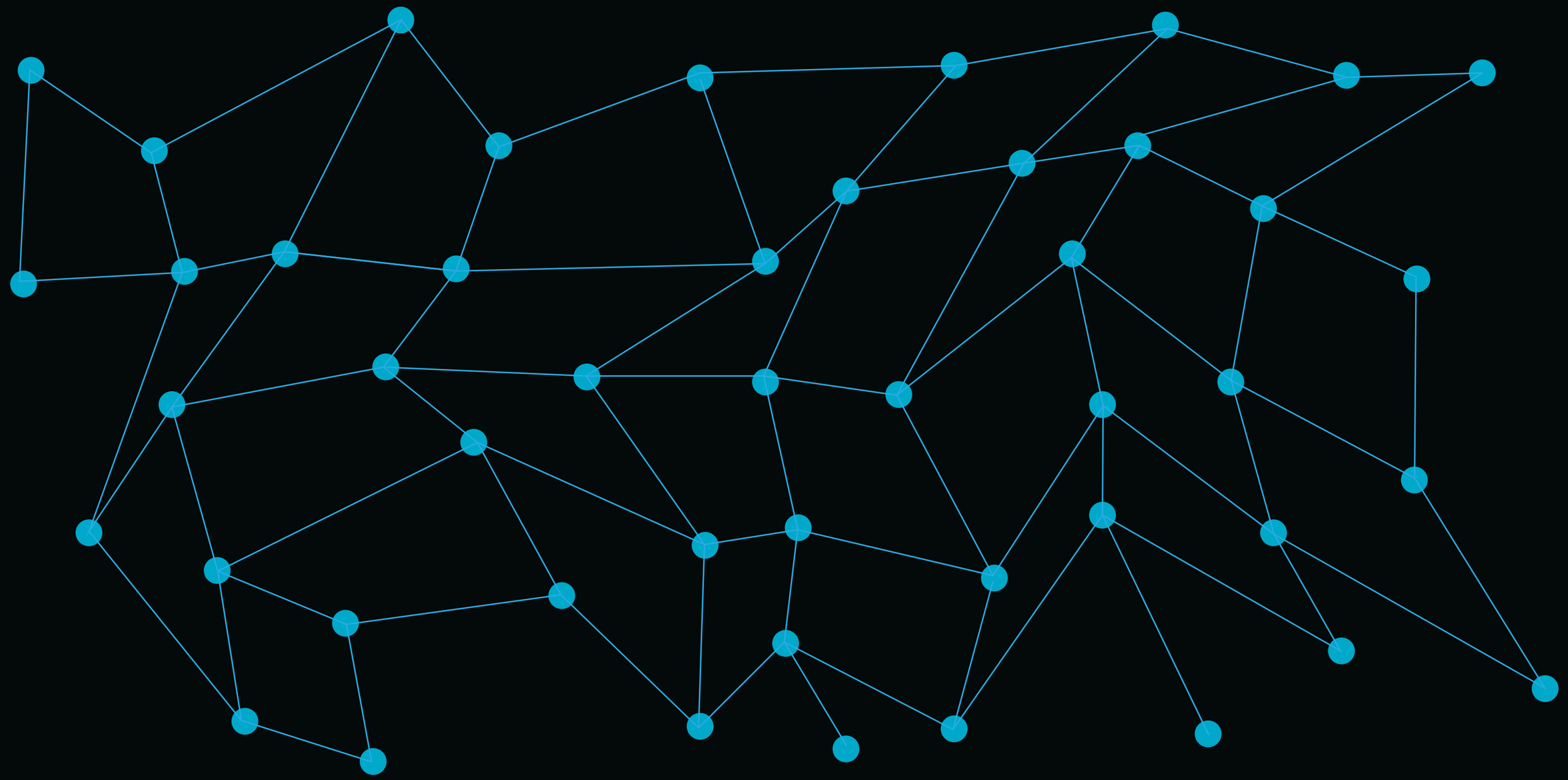
Decentralized System



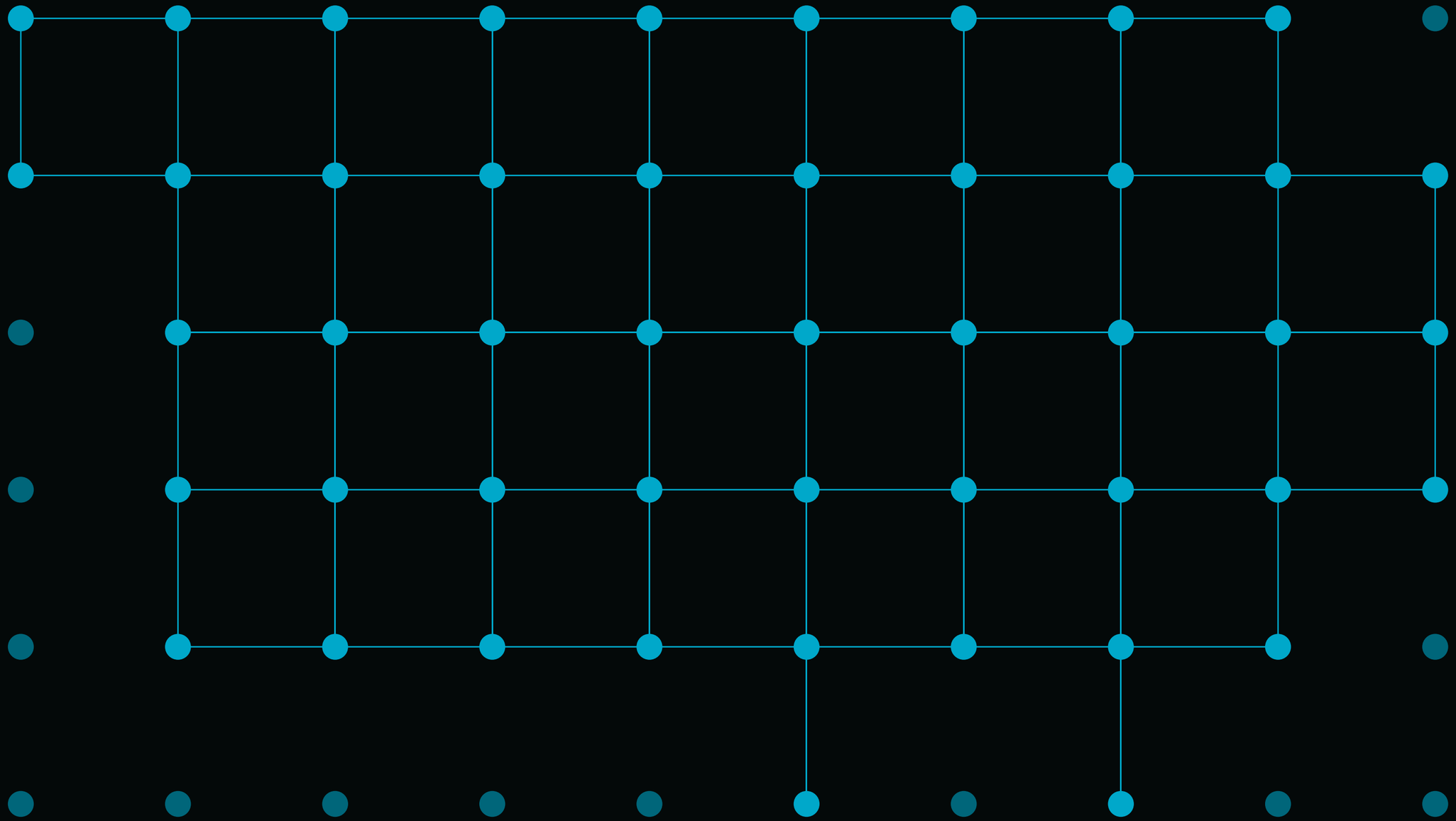
Distributed System



Grid (matrix)



Grid (regularized)

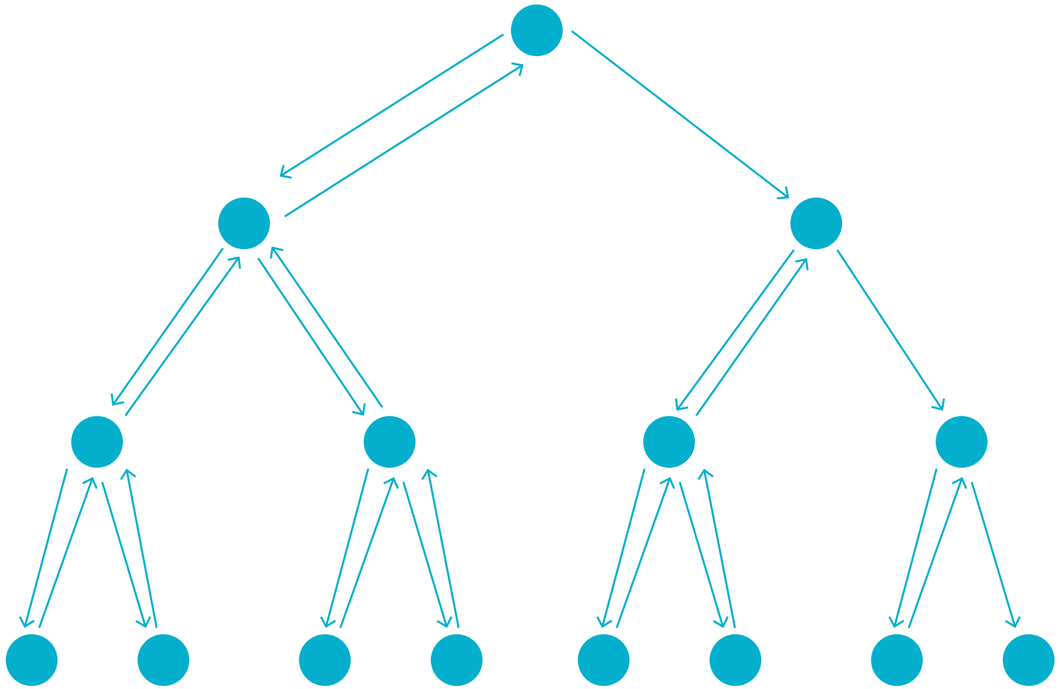


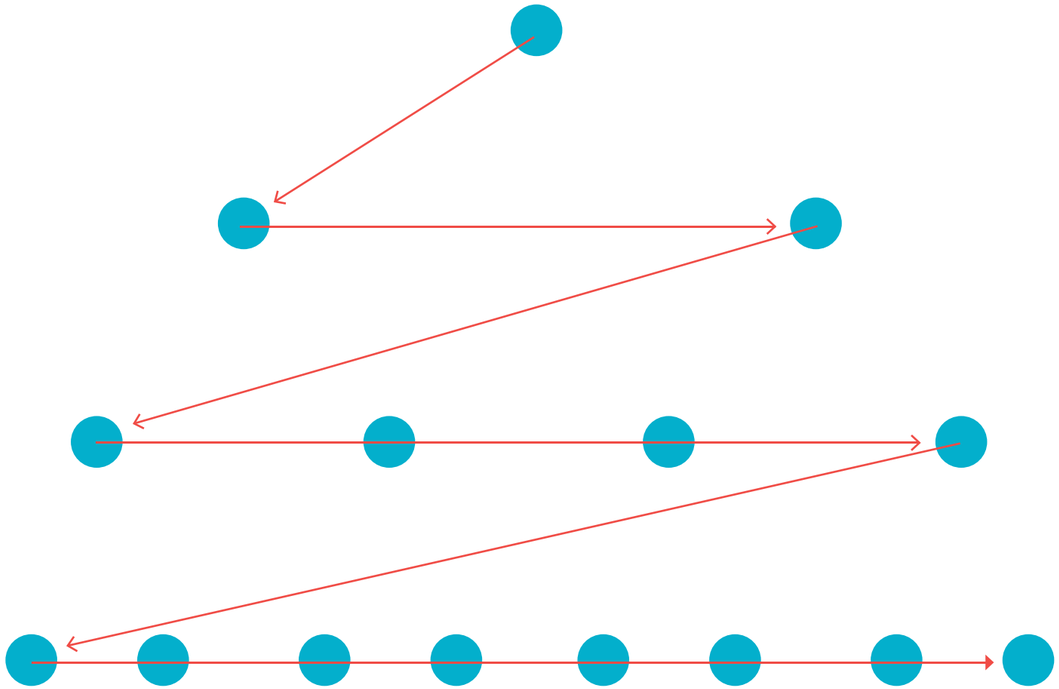
The basic structures may be mapped onto one another.

A tree can be encoded onto an array.

A tree can also be encoded onto a matrix.

Trees can be traversed depthwise or breadthwise



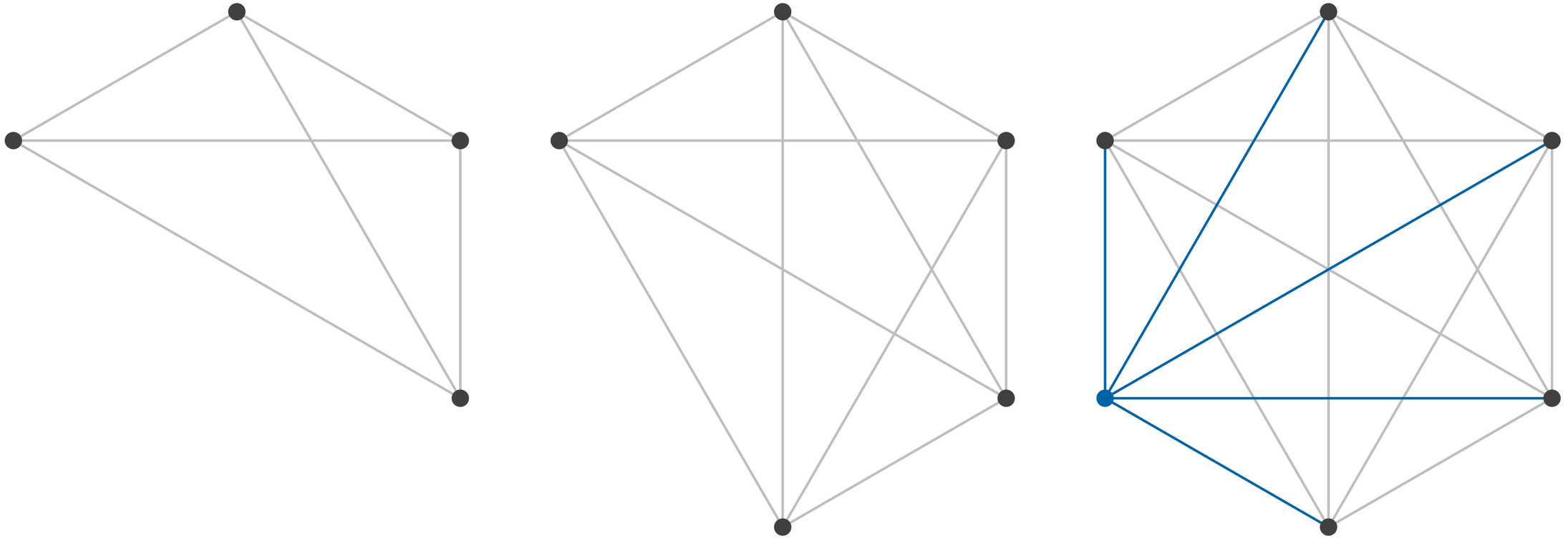


Often, we need to study a particular path through a network.

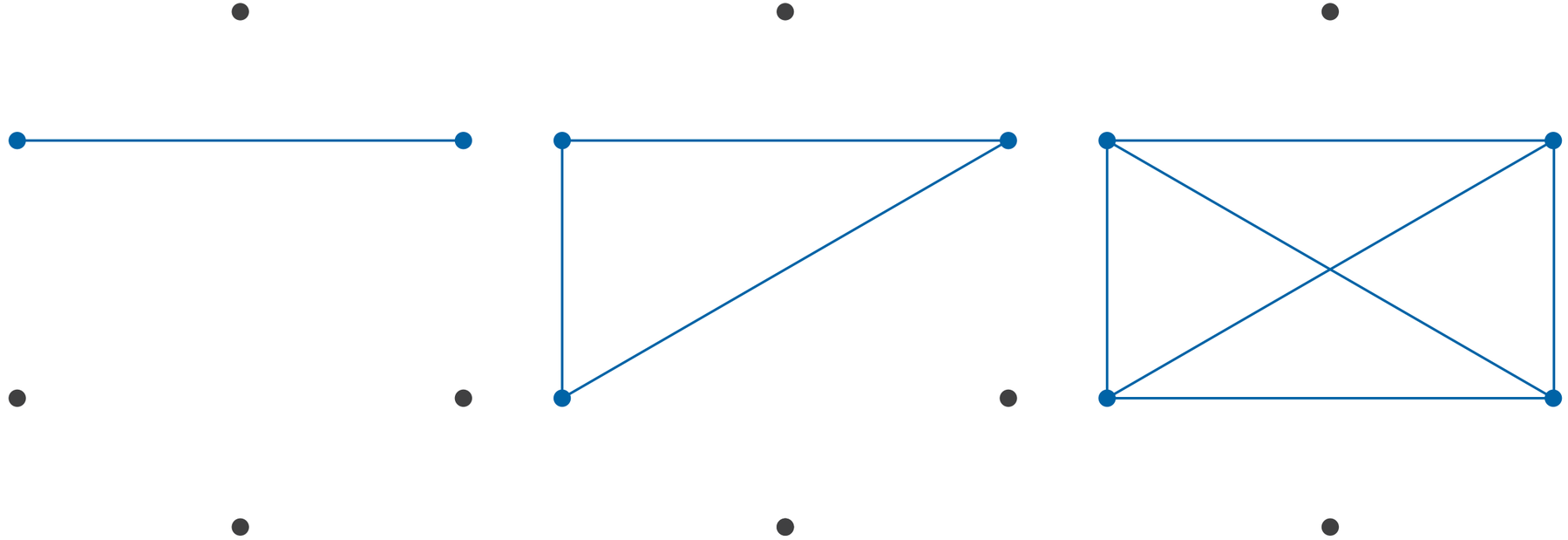
In order to go from one location to another,
we need a route and an address.

10 Downing Street
123 45 6789
1 415 309 6057
c://university/school/department/faculty_member/student

In a network, each node enhances the value of the existing nodes by increasing the number of connections.



As the number of nodes grow, each new node brings an increasing number of new connections.



2 nodes
1 connection

3 nodes
3 connections

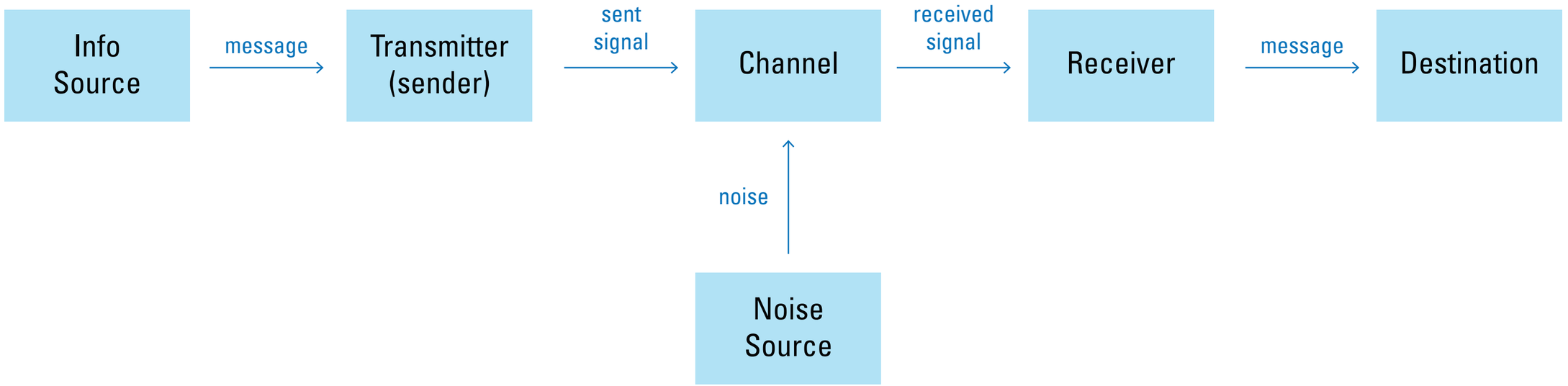
4 nodes
6 connections

n nodes yield $\frac{(n^2 - n)}{2}$ connections

1000 nodes yield nearly half a million connections

Communications within networks

The Mathematical Model of Communication — Shannon + Weaver

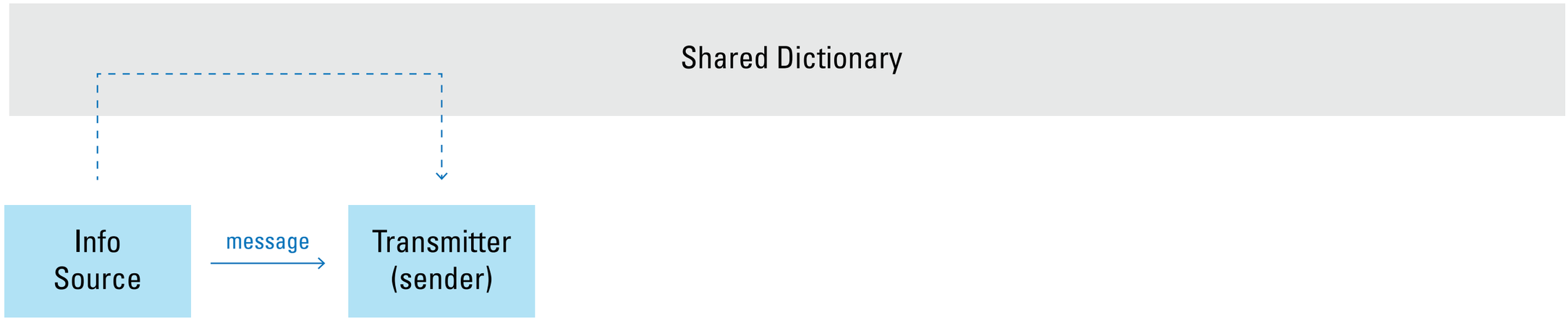


The model relies on a shared dictionary — a controlled vocabulary.

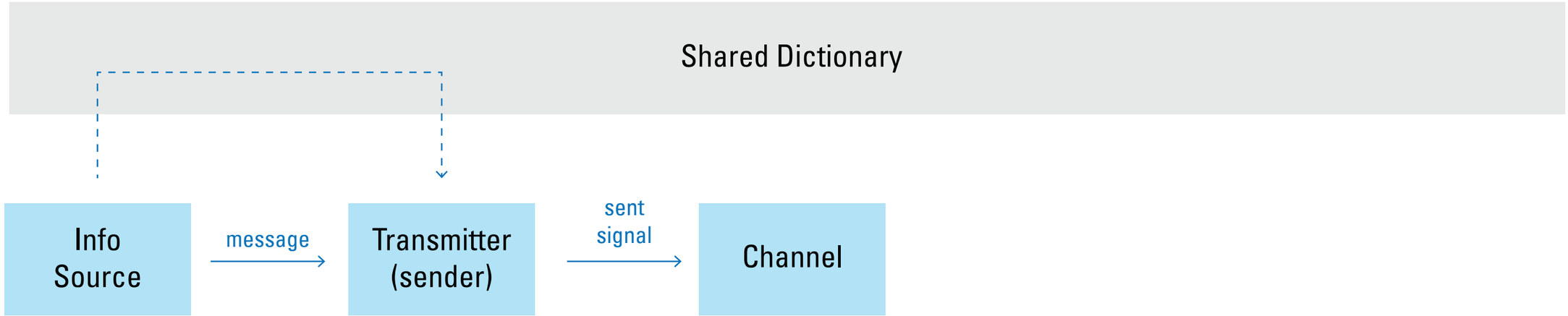
Shared Dictionary

Info Source

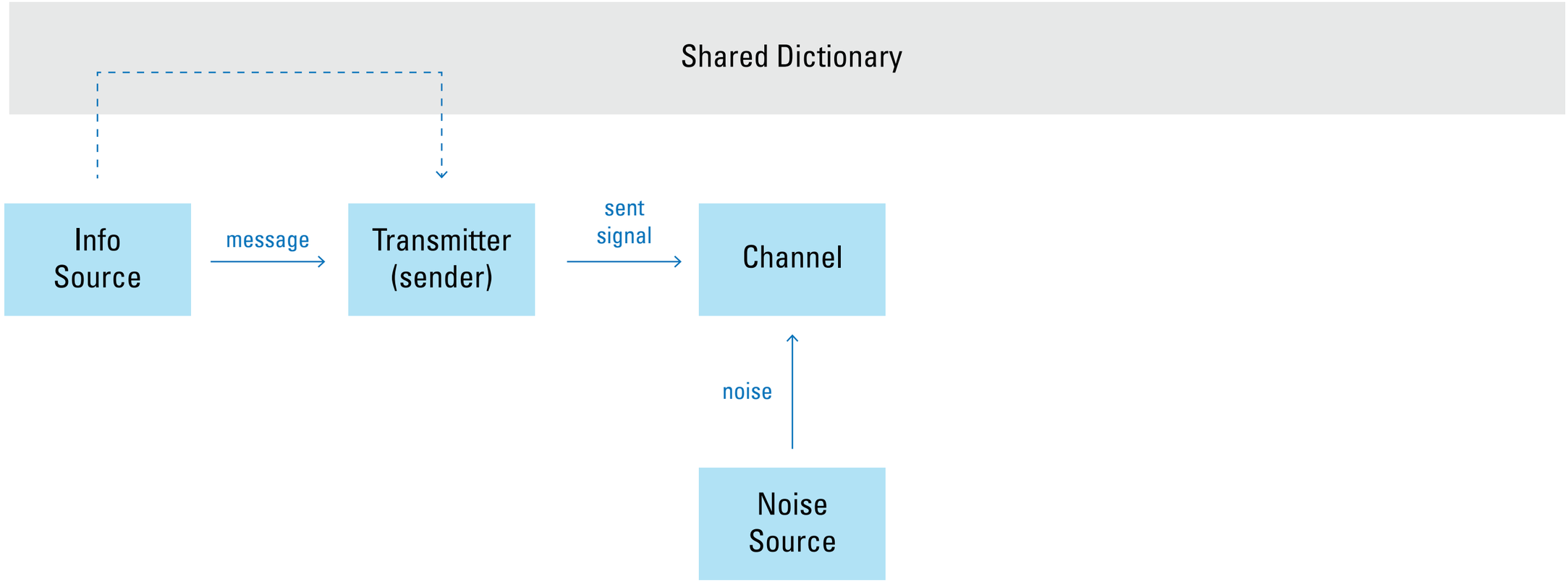
An information source selects one possible message from the dictionary.



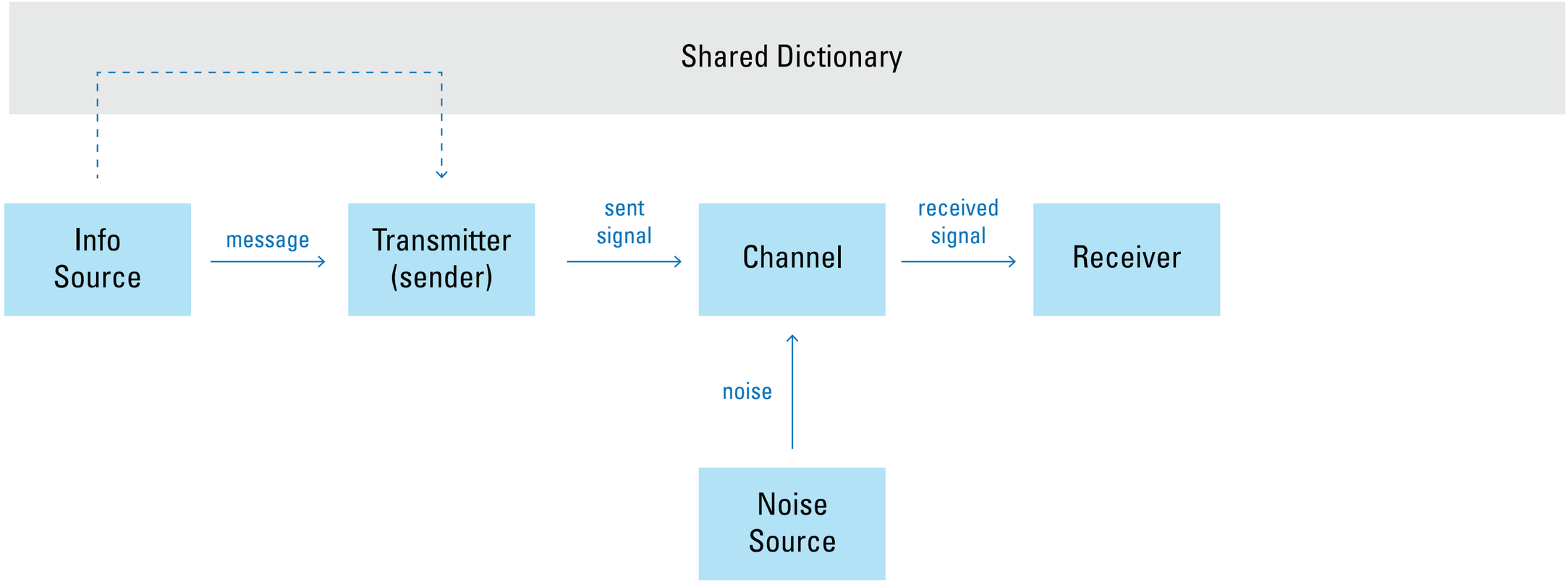
The transmitter uses a transducer to send signals into the channel.



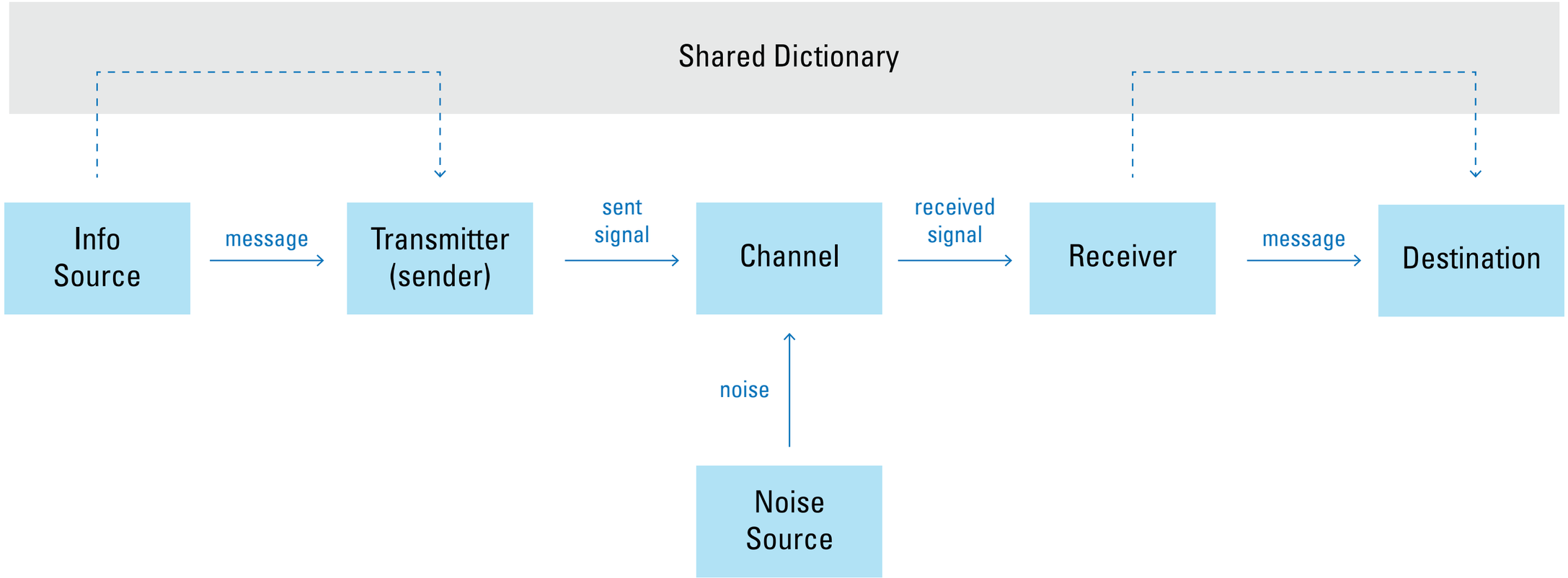
While passing through the channel, the signal is subject to noise (distortion).



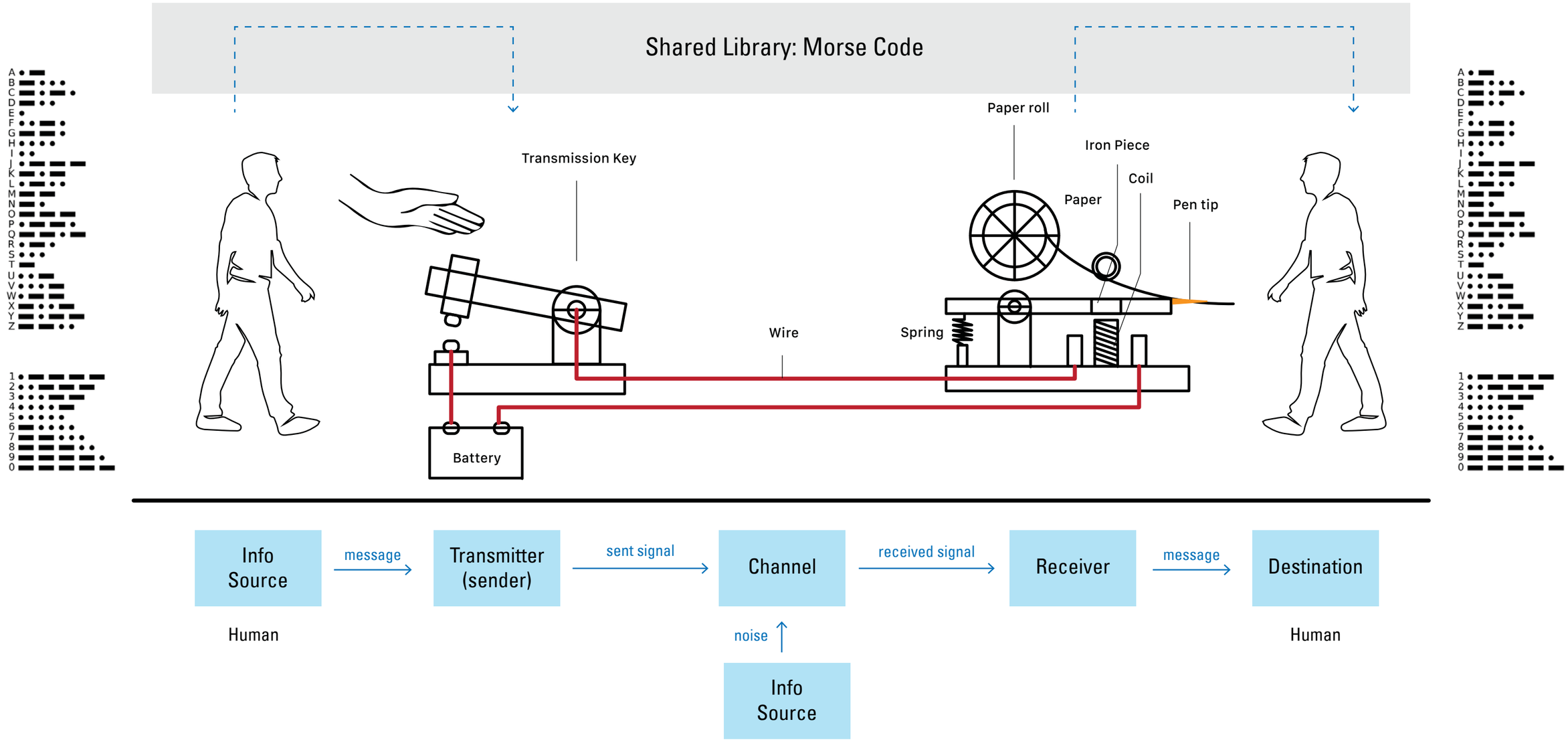
On the other side, another transducer converts the signal into a "readable" form.



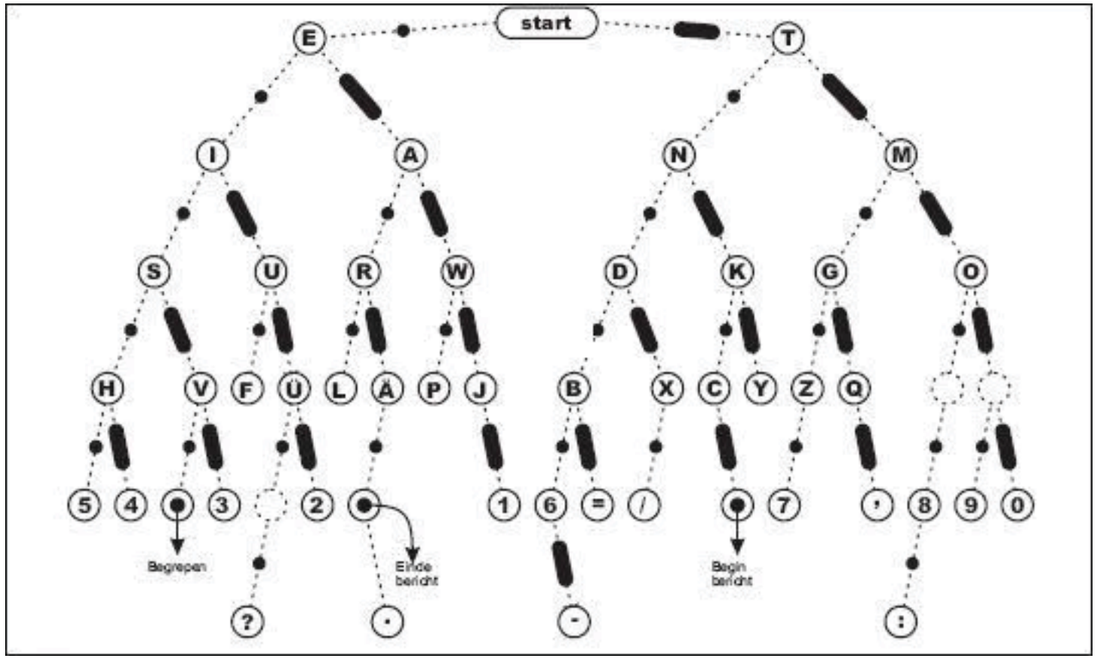
The receiver then looks up the message in the shared dictionary.

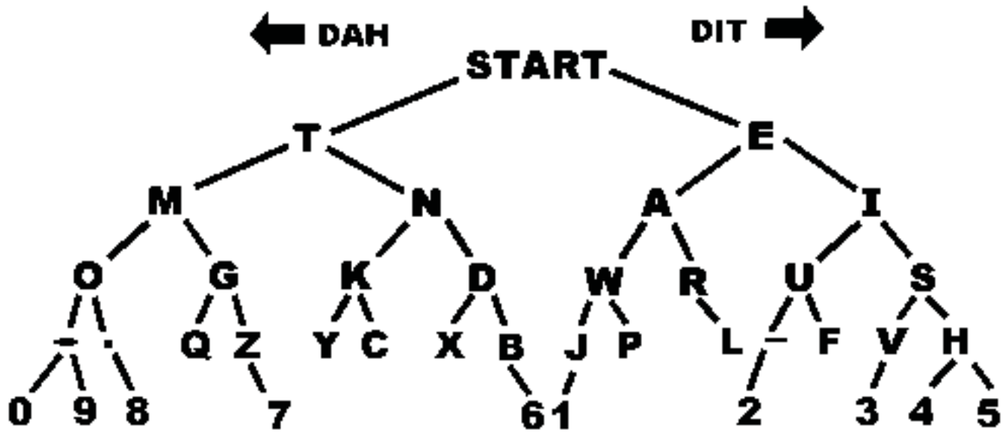


Telegraph and Morse code

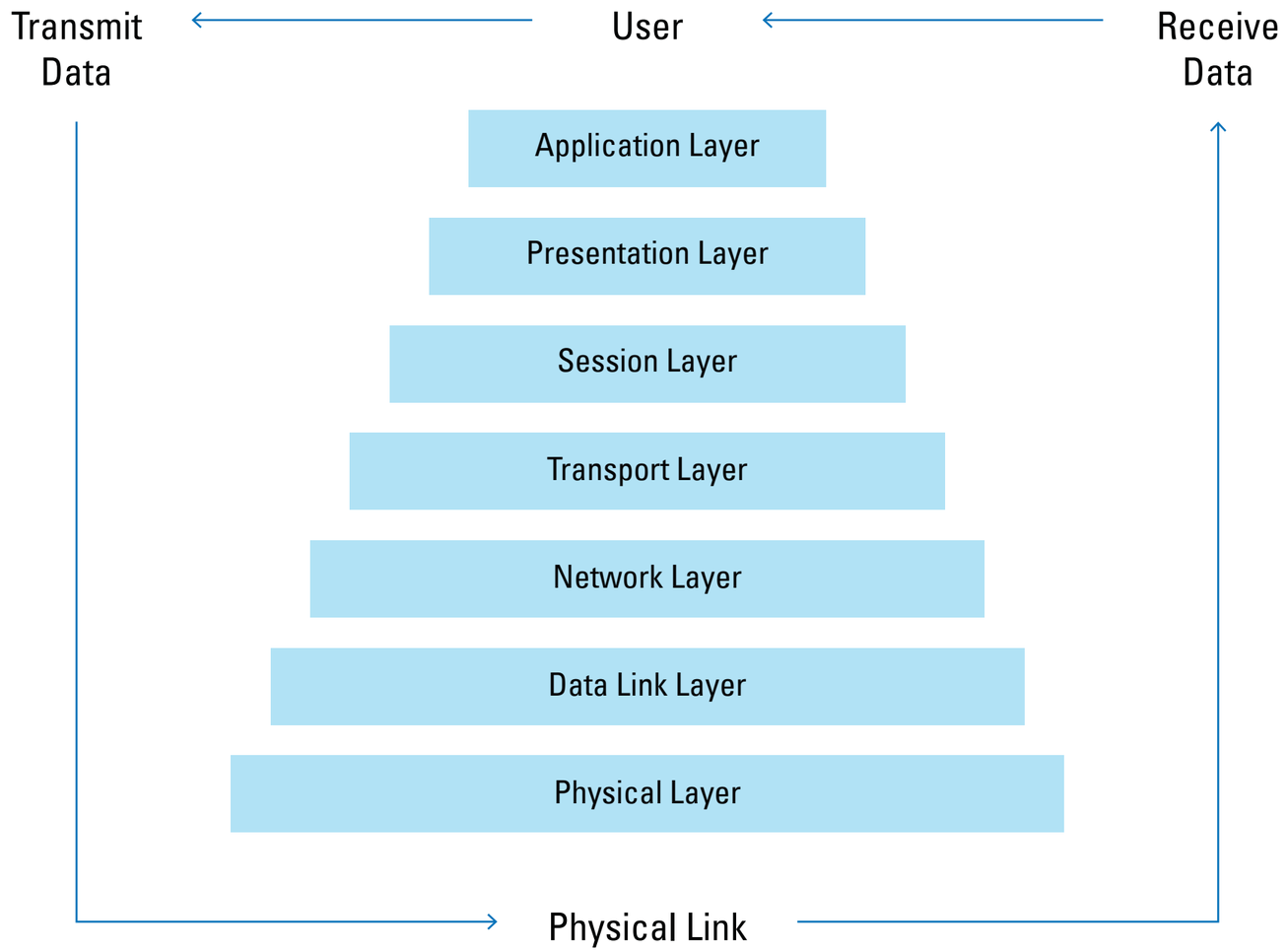


Morse code itself is organized as a tree





OSI 7 layer model of networking



Special thanks to
Jamie Ikeda
Wilson Wu

hugh@dubberly.com

Presentation posted at
systems.dubberly.com/nodes_links_networks.pdf