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# Putting Big Data in its Place

Mike Amundsen,  
API Academy at CA  
@mamund



# Introduction





Mike Amundsen  
@mamund





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# Your Guide to API Design & Implementation Best Practices

API Academy delivers free online lessons and in-person consulting services covering essential API techniques and tools for business managers, interface designers and enterprise architects



### What is an API?

Get an overview of what an API is and what it does, to help you realize the business value of APIs



### API Design Basics

Understand the API architecture process and learn basic design and implementation best practices



### Web API Architectural Styles

Get a detailed overview of the main architectural styles for Web and mobile API design



### Choosing a Solution

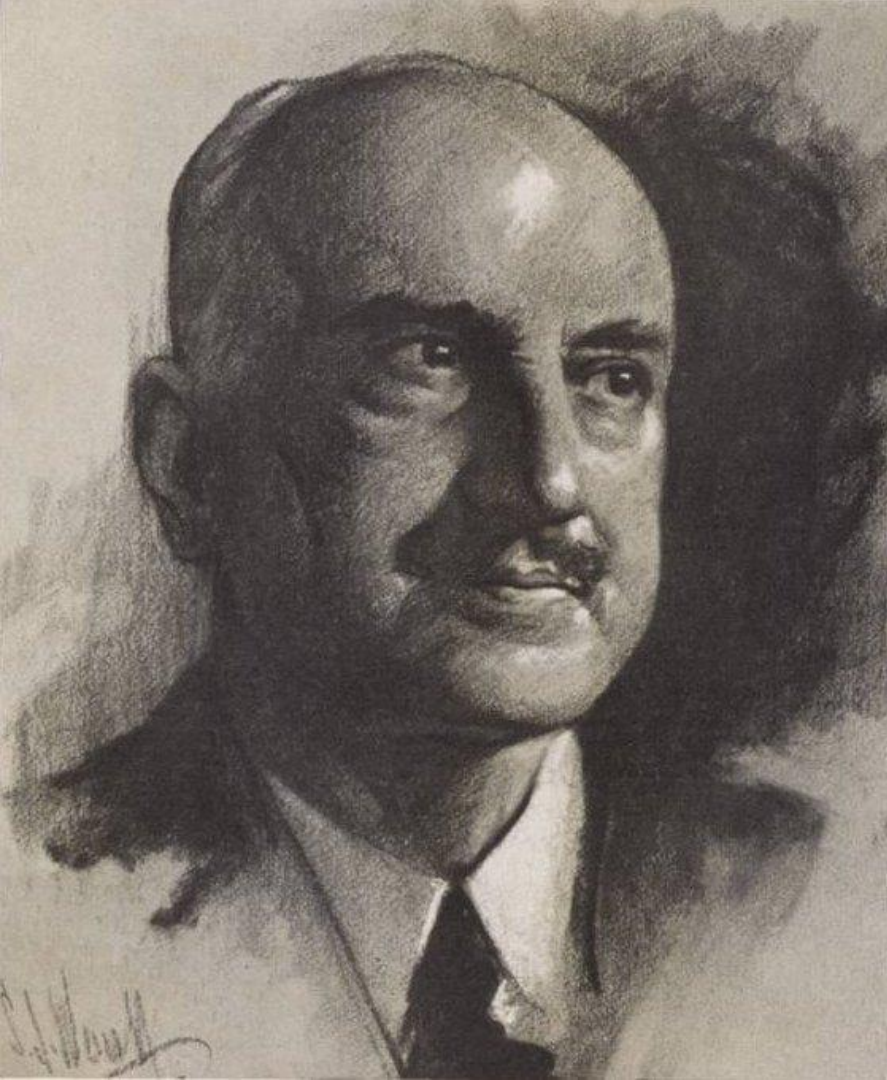
Choose between the various solutions that offer the basic components for enterprise API Management

# Big Data Challenges









“Those who cannot  
remember the past are  
condemned to repeat it.”

George Santayana, 1905

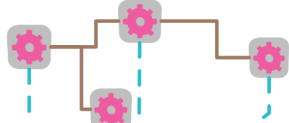




“Those who ignore the mistakes of the future are bound to make them.”

Joseph D. Miller, 2006

Operational systems communicate with each other via service connections, ignoring the data lake



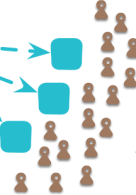
Operational systems feed data into the lake using their own schemas



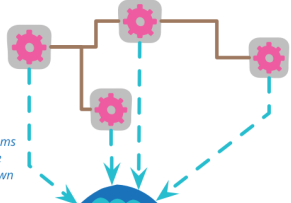
A few data scientists investigate the lake for potential insights



Lakeshore marts curate and organize the data for most analytics uses



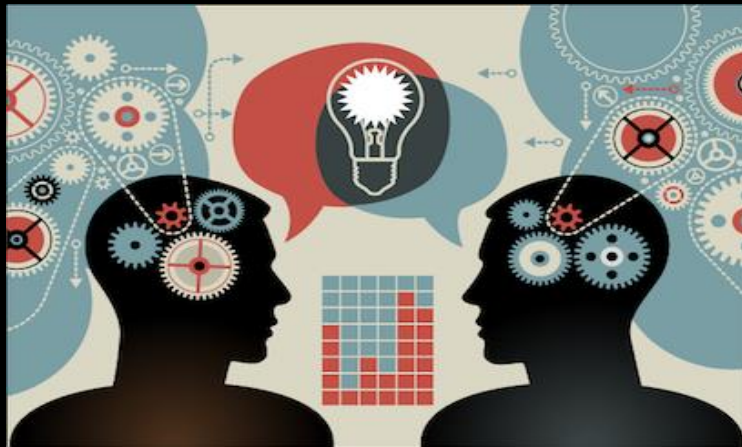
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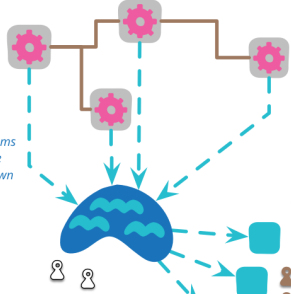
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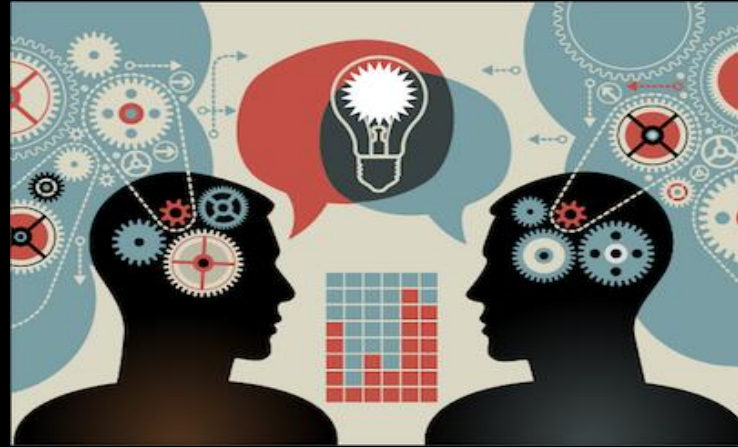
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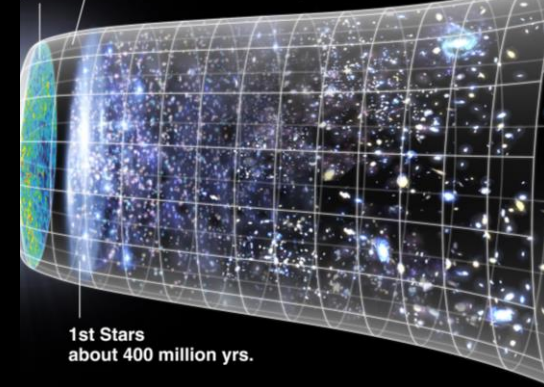
Lakeshore marts curate and organize the data for most analytics uses



ght  
ern  
yrs.

Dark Ages

Development of  
Galaxies, Planets, etc.



1st Stars  
about 400 million yrs.



# Data and Storage



# da·ta

/'datə, 'dātə/ 

- COMPUTING

the quantities, characters, or symbols on which operations are performed by a computer, being stored and transmitted in the form of electrical signals and recorded on magnetic, optical, or mechanical recording media.





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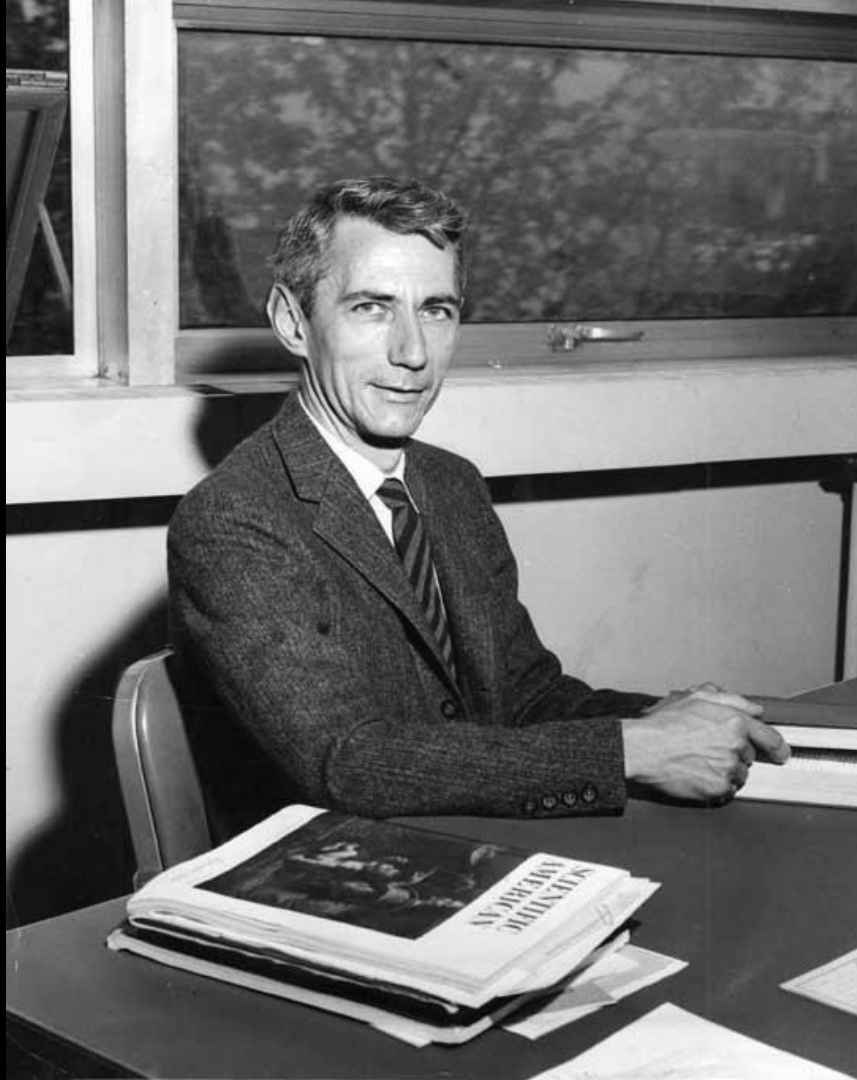


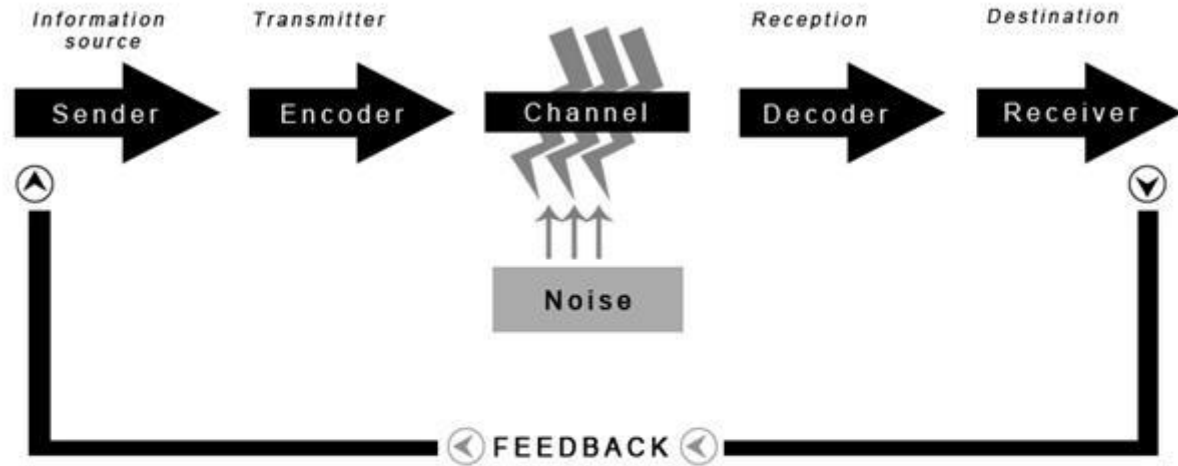
**It's called a database**



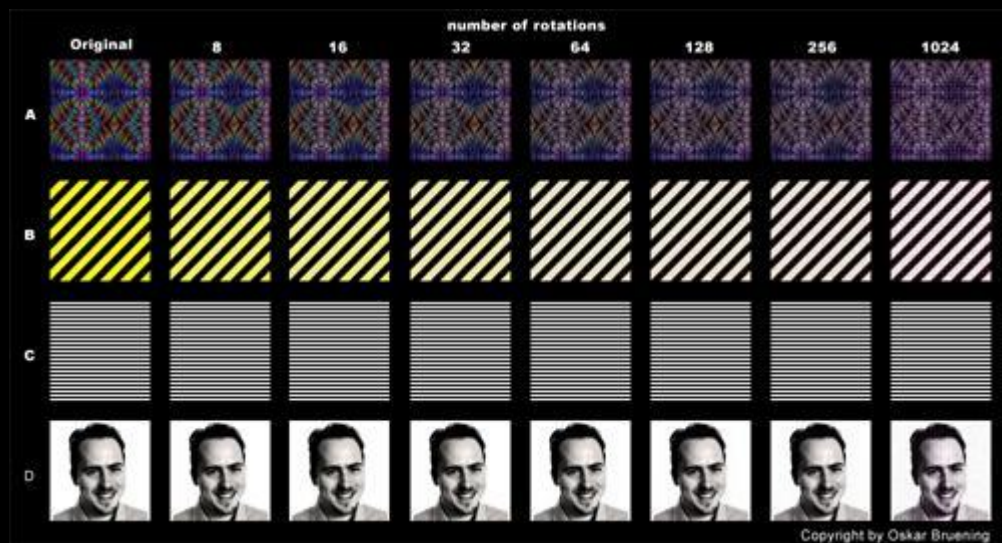
**It's called a database  
not an informationbase**





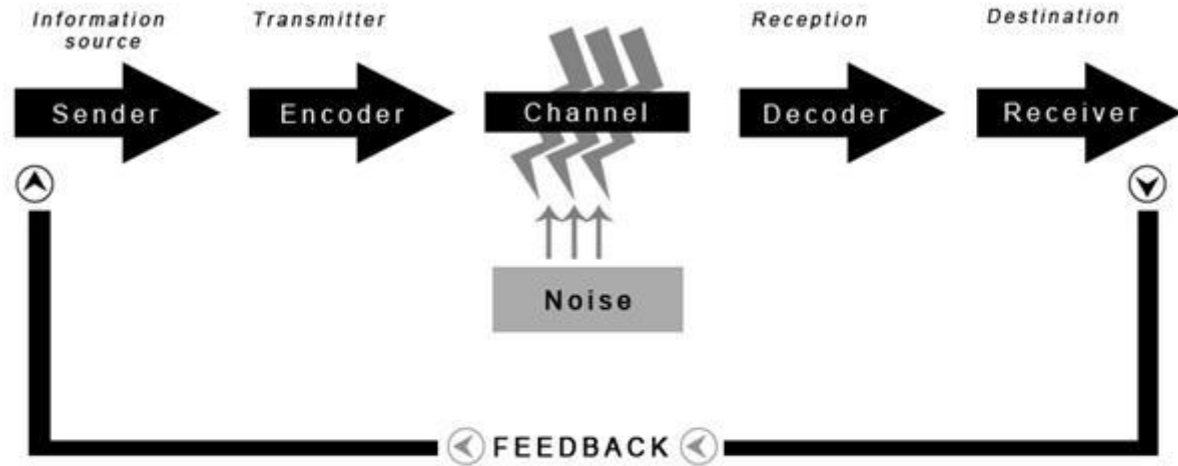


SHANNON-WEAVER'S MODEL OF COMMUNICATION



V W X Y Z A B C D E F G H I J K L M N O P Q R S  
W X Z K R Y P T O S A I  
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Z K R Y P T O S A B C





SHANNON-WEAVER'S MODEL OF COMMUNICATION





0.08

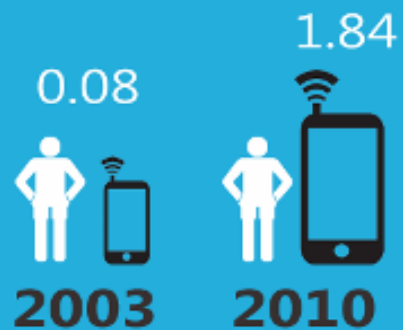


**2003**

**Connected devices per person.**

Source: Cisco IBSG, April 2011

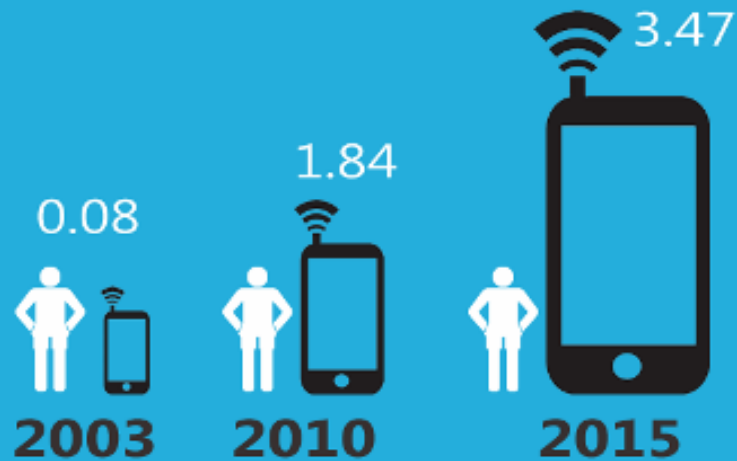




**Connected devices per person.**

Source: Cisco IBSG, April 2011

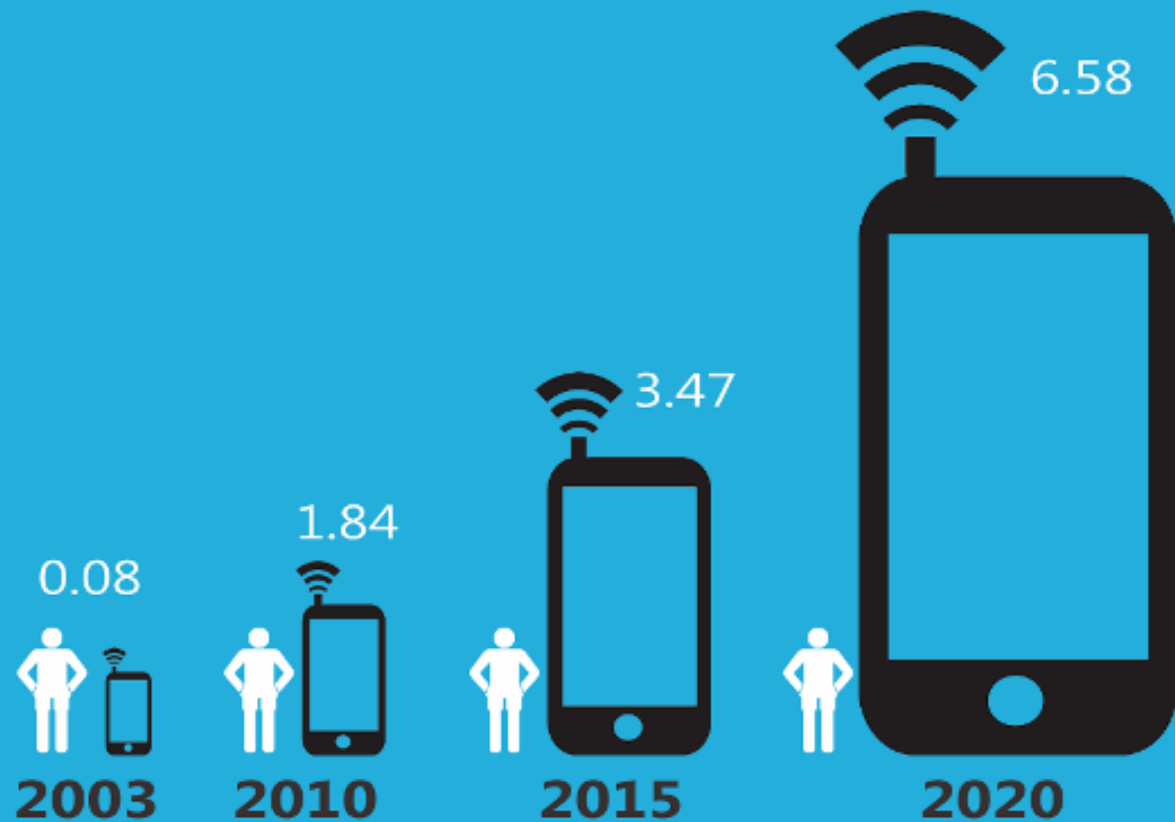




**Connected devices per person.**

Source: Cisco IBSG, April 2011



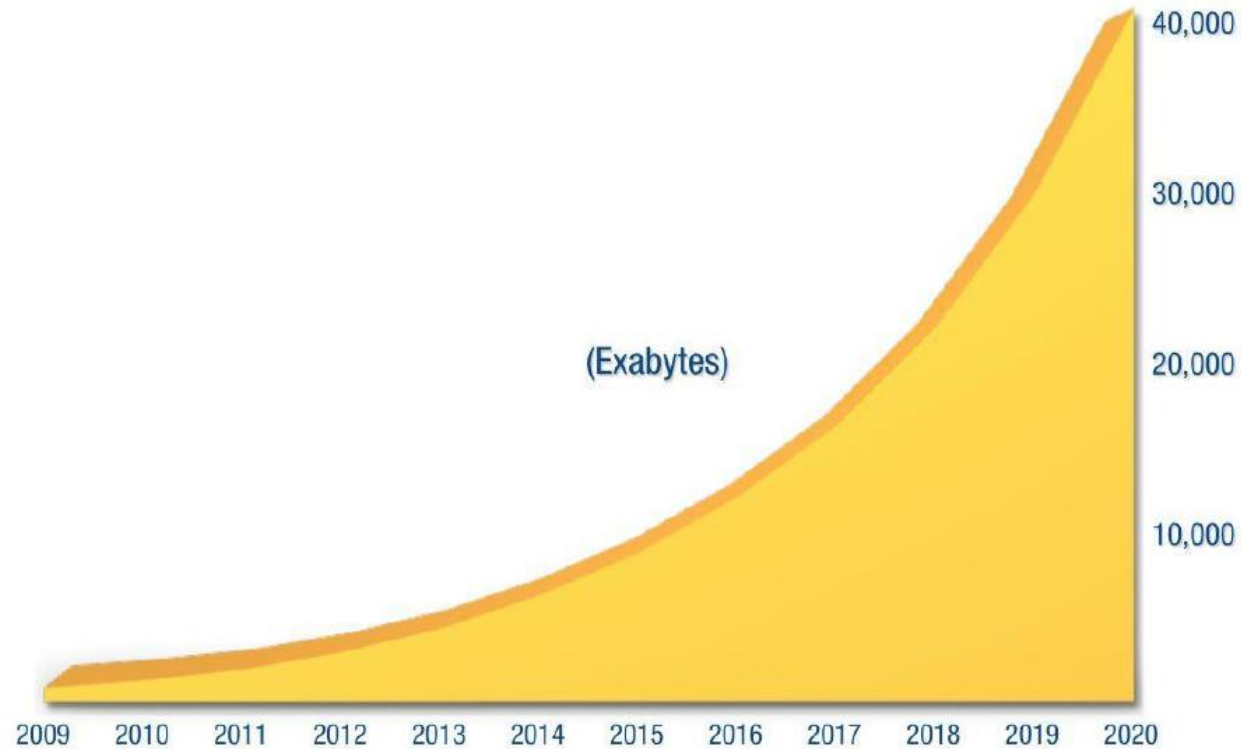


**Connected devices per person.**

Source: Cisco IBSG, April 2011



## The Digital Universe: 50-fold Growth from the Beginning of 2010 to the End of 2020



This IDC graph predicts exponential growth of data from around 3 zettabytes in 2013 to approximately 40 zettabytes by 2020. An exabyte equals 1,000,000,000,000,000 bytes and 1,000 exabytes equals one zettabyte. Source: IDC's Digital Universe Study, December 2012, <http://www.emc.com/collateral/analyst-reports/idc-the-digital-universe-in-2020.pdf>.









**1 Gigabyte per day**





**365 truck loads per person per year**







AP

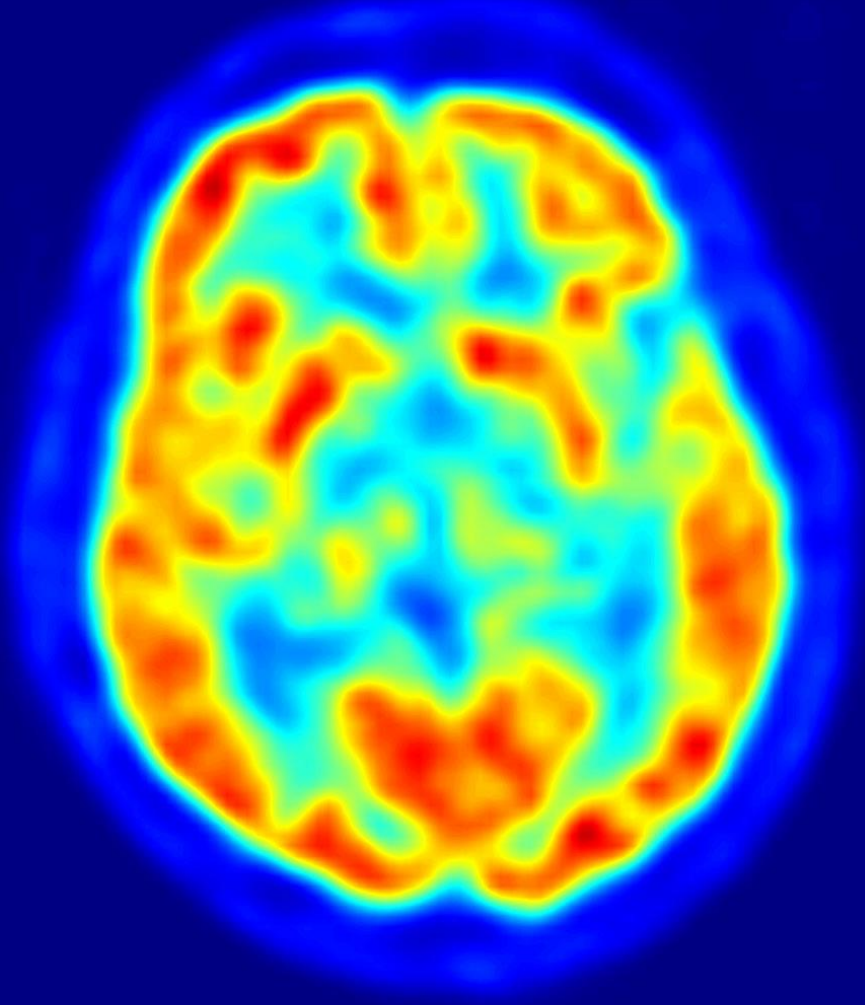


# 1 Yottabyte of Storage



AP





# 100 Terabytes



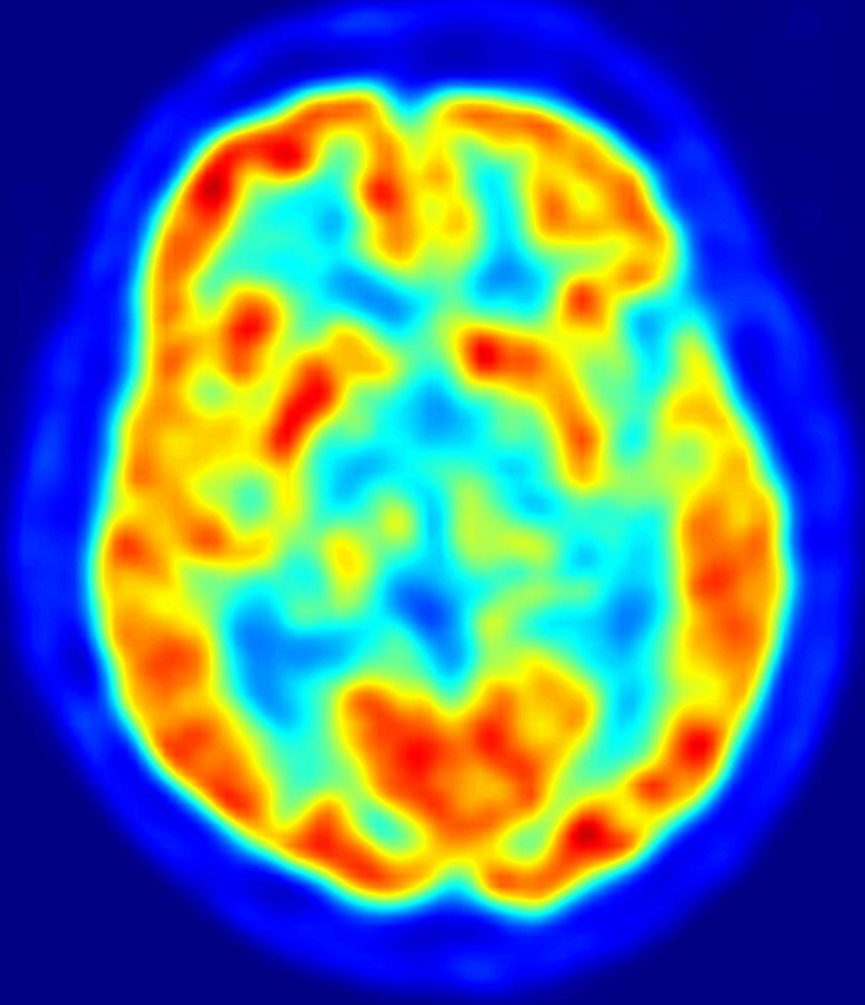


**100 Terabytes**  
**100,000 Gigabytes**



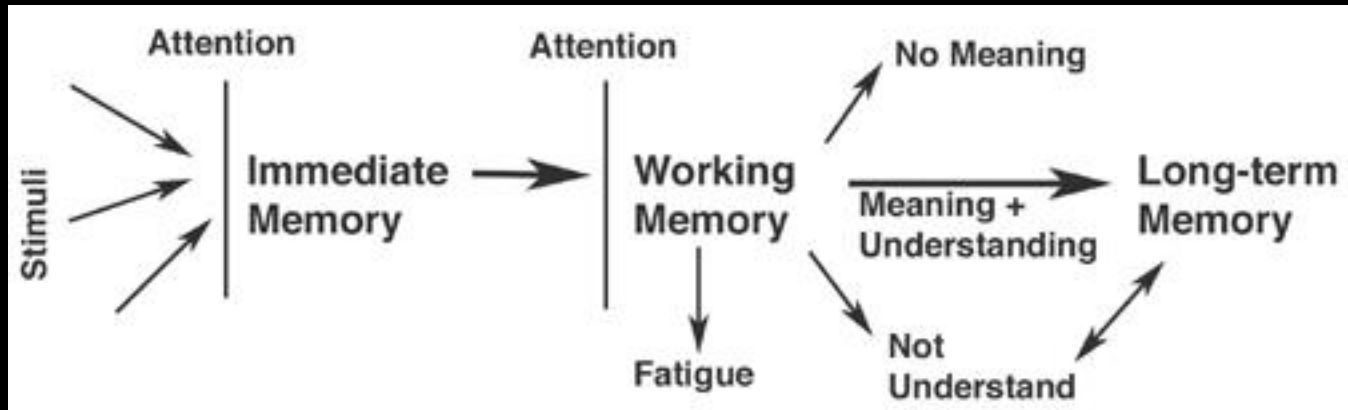
**100 Terabytes**  
**100,000 Gigabytes**  
**250+ years of storage per person**



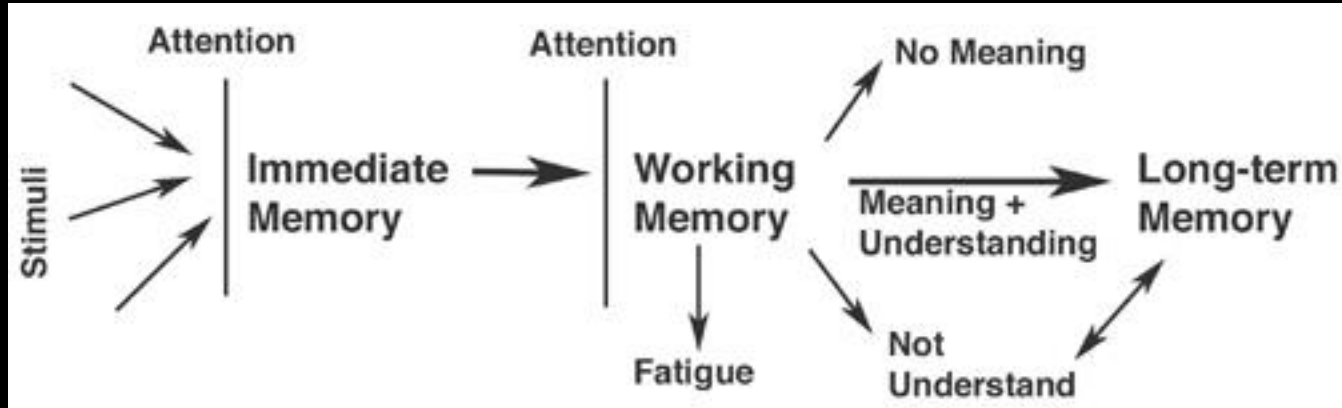


# NO





# Pruning data into long-term memory



THE SURPRISING SCIENCE OF  
THE MIND AT REST

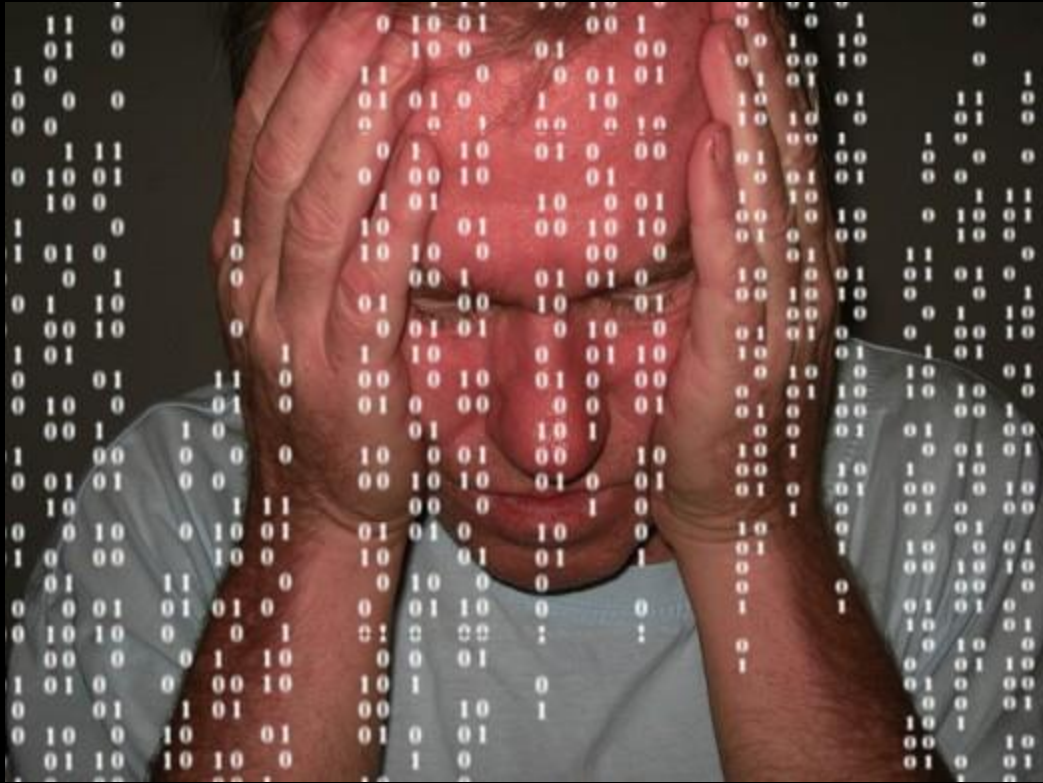
the secret

world

of sleep

PENELOPE A. LEWIS

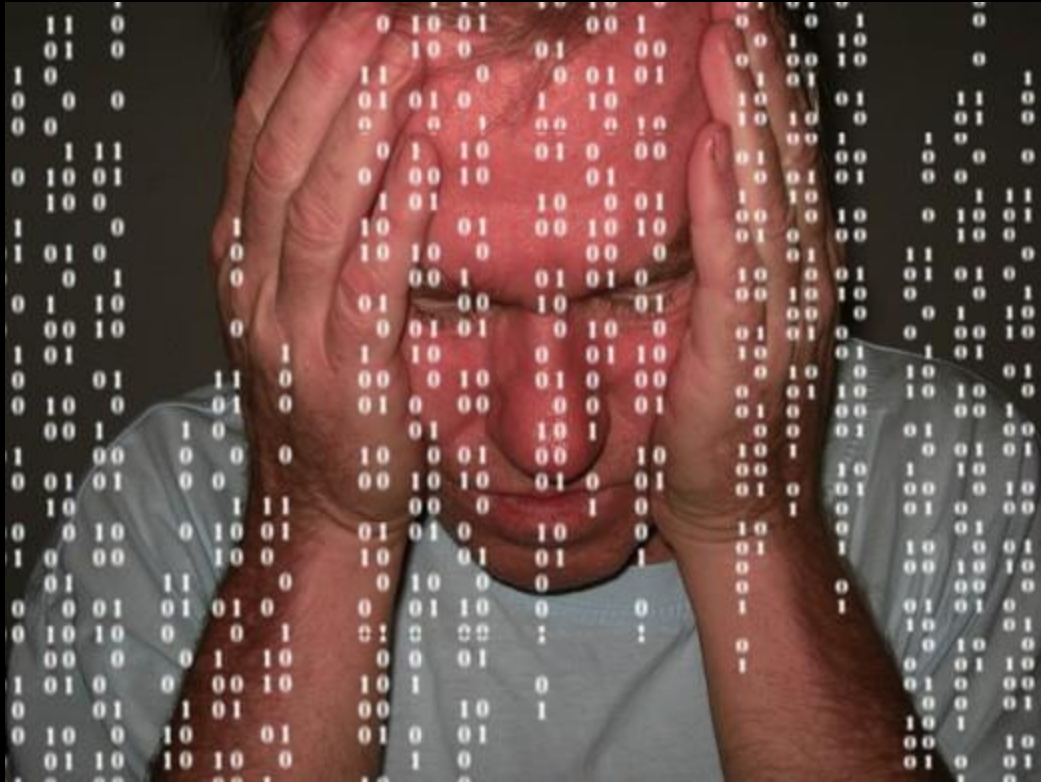






***“Forgetting makes our brains more efficient.”***





***Learning to choose is hard.***



***Learning to choose is hard.  
Learning to choose well is harder.***





“Learning to choose well in a world of unlimited possibilities is, perhaps, too hard.”

Barry Schwartz, 2004

# THE PARADOX OF CHOICE

WHY MORE IS LESS **BARRY SCHWARTZ**

HOW THE CULTURE OF ABUNDANCE ROBS US OF SATISFACTION



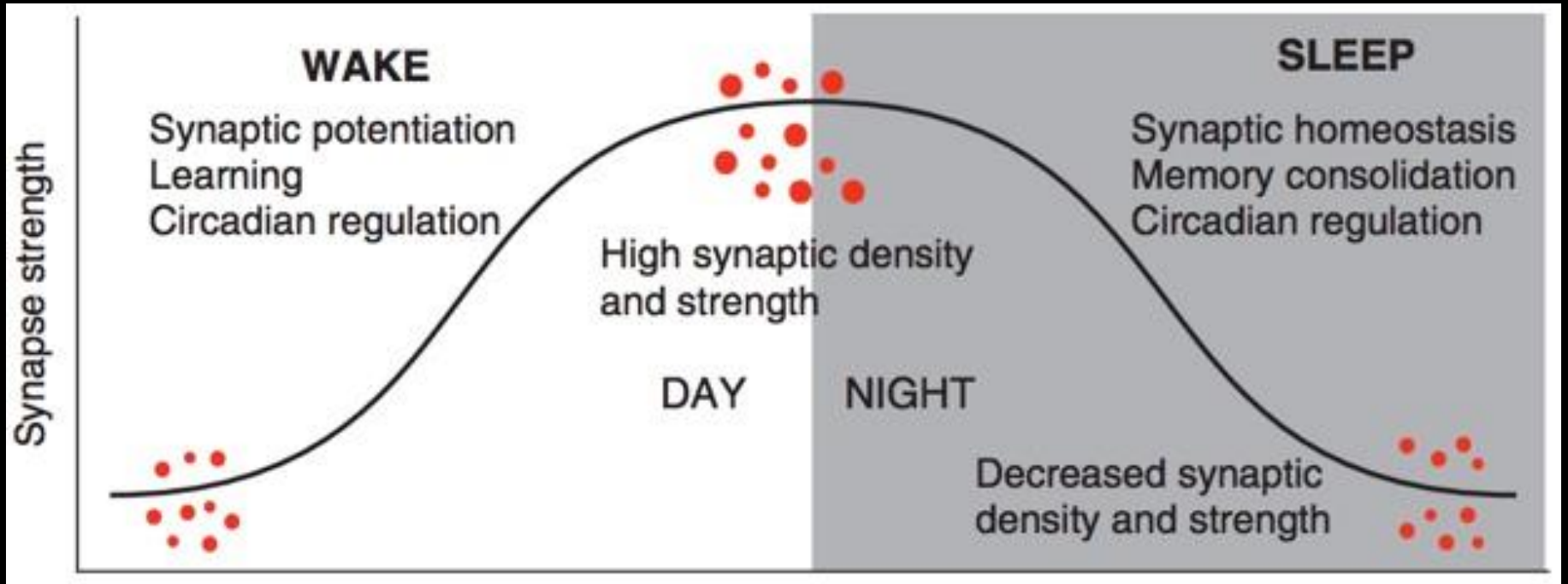
"A revolutionary and beautifully reasoned book about the promiscuous amount of choice that renders the consumer helpless. A must read."

— Martin Seligman, author of *Authentic Happiness*

P.S.  
INSIGHTS,  
INTERVIEWS,  
& MORE...



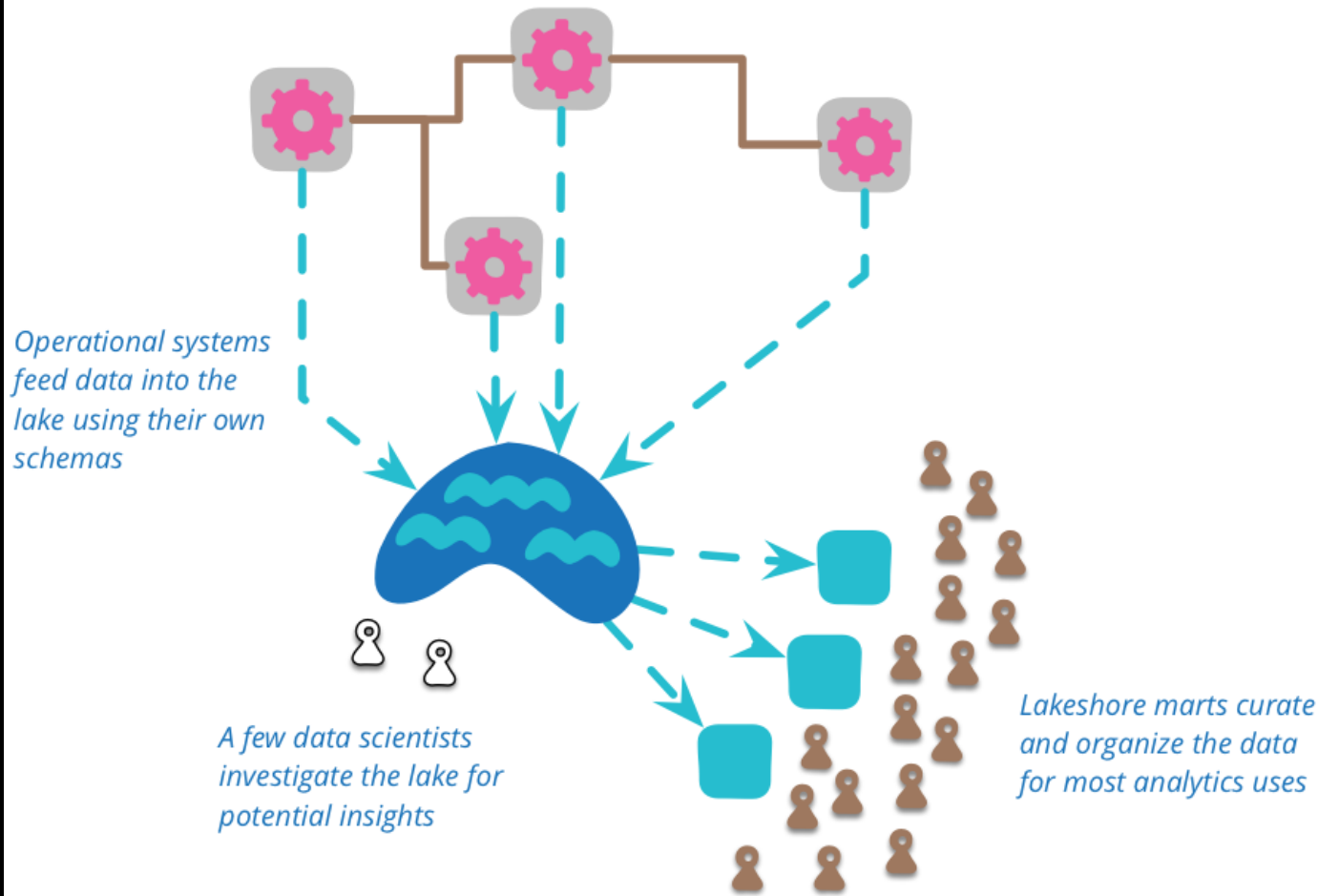








*Operational systems communicate with each other via service connections, ignoring the data lake*



# Data and Storage Challenges

- Support Pruning Strategies
- Implement Data Lakes
- Reduce Data Overload



# Modeling Information



# mod·el

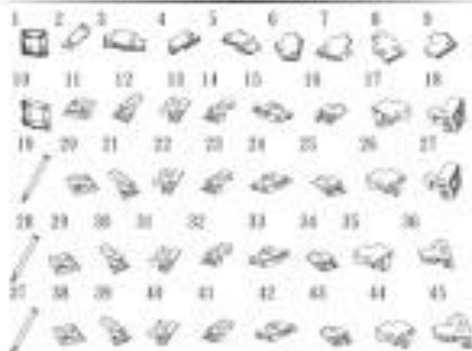
/'mædl/ 

2. a system or thing used as an example to follow or imitate.  
"the law became a model for dozens of laws banning nondegradable plastic products"





Part A The First Observatory 46 pieces



Put observatory #1 upside down and start to assemble from the corner until the last piece fits. Insert the shortest center pole and tighten using the key included.



Part B The Second Observatory 42 pieces

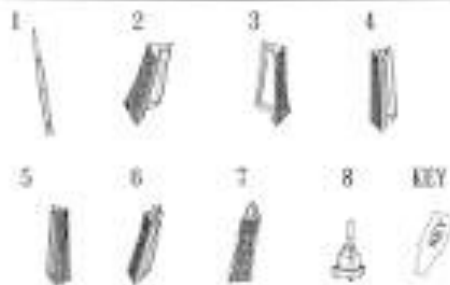


Put the tower back to the normal position to continue assembling. Assemble carefully as the two pillars of the second observatory can easily tilt. After assembling piece #36,

- 1) Assemble pieces #37 and #38 separately.
- 2) Insert 4 longer center poles into it.
- 3) Insert the entire part extremely carefully into the 4 pillars and tighten using the key.



Part C The Upper Part 8 pieces



Insert the longest center pole from the bottom, then assemble the rest of the pieces.



To complete the puzzle, put one piece #8 from part C as tightly as the tower in place.

```
{
  "_id" : "_design/microblog",

  "views" : {

    "users_search" : {
      "map" : "function(doc){
        if(doc._id && doc.type==='user') {
          emit(doc._id,doc);
        }
      }"
    },

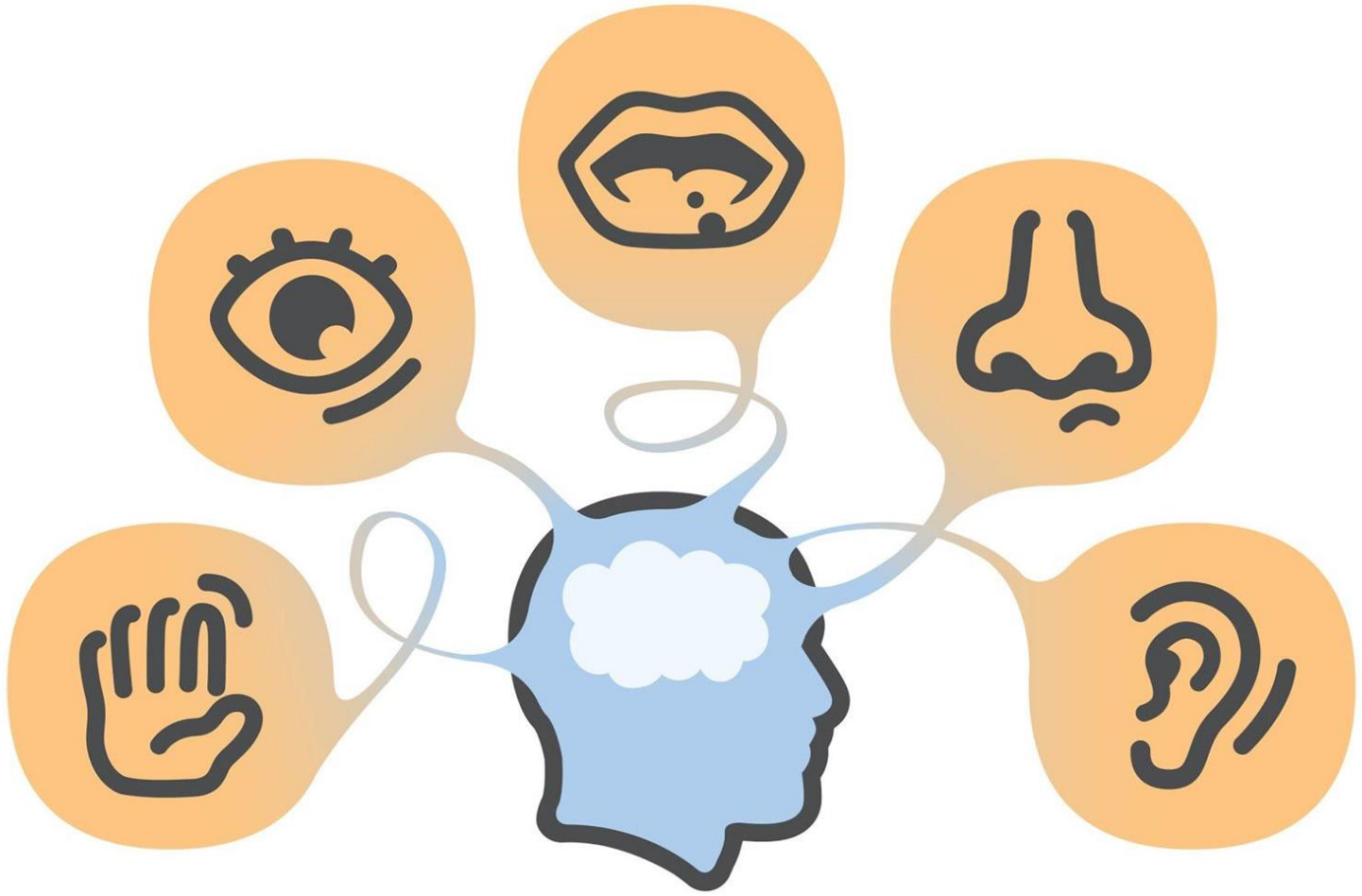
    "users_by_id" : {
      "map" : "function(doc){
        if(doc._id && doc.type==='user') {
          emit(doc._id,doc);
        }
      }"
    }
  }
}
```



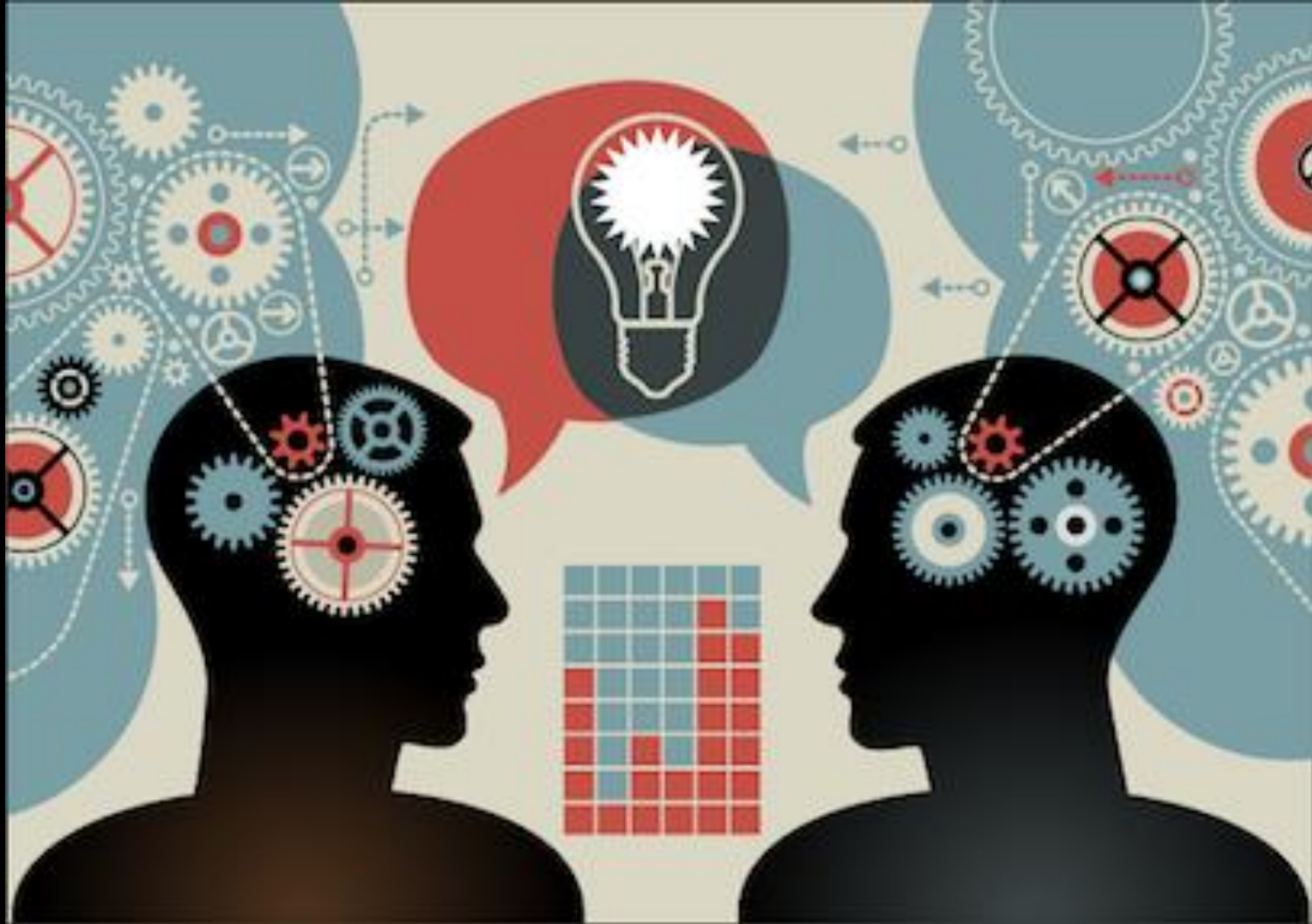


**Models allow us to  
add meaning to data**











**data + model = information**



# in·for·ma·tion

/,ɪnfər'māSHən/ 

2. what is conveyed or represented by a particular arrangement or sequence of things.

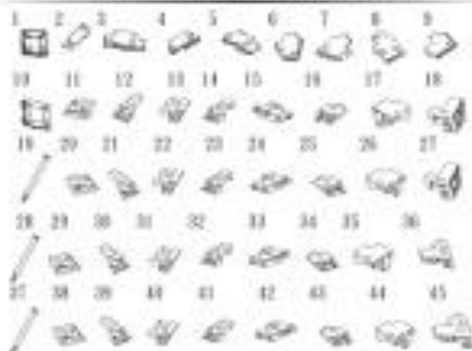
"genetically transmitted information"







Part A The First Observatory 46 pieces



Put observatory #1 upside down and start to assemble from the corner until the last piece fits. Insert the shortest center pole and tighten using the key included.



Part B The Second Observatory 42 pieces

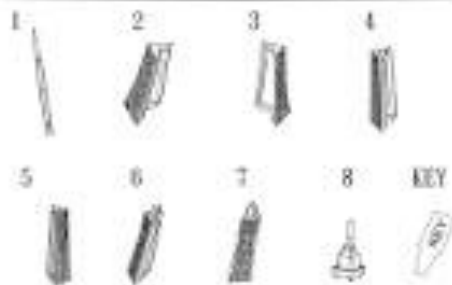


Put the tower back to the normal position to continue assembling. Assemble carefully as the two pillars of the second observatory can easily tilt. After assembling piece #36,

- 1) Assemble pieces #37 and #38 separately.
- 2) Insert 4 longer center poles into it.
- 3) Insert the entire part extremely carefully into the 4 pillars and tighten using the key.



Part C The Upper Part 8 pieces



Insert the longest center pole from the bottom, then assemble the rest of the pieces.



To complete the puzzle, put on piece #8 from part C as tightly to the tower as possible.

```
{ "total_rows": 678, "offset": 0, "rows": [
  { "id": "0c8b4d6cefc1123854429a9f0f2d6dd6", "key": "0c8b4d6cefc1123854429a9f0f2d6dd6", "value": { "rev": "2-f2261c5bc9f640188416bb1511d0faa9" } },
  { "id": "0c8b4d6cefc1123854429a9f0f3fb4db", "key": "0c8b4d6cefc1123854429a9f0f3fb4db", "value": { "rev": "1-f86b1553cdaeb859ae5ead24895abf3c" } },
  { "id": "0c8b4d6cefc1123854429a9f0f65dab5", "key": "0c8b4d6cefc1123854429a9f0f65dab5", "value": { "rev": "1-5e2f59b8c82e6e28aa93d3aceb393df0" } },
  { "id": "0e35b6df6ec57319336e82d798d6ccede", "key": "0e35b6df6ec57319336e82d798d6ccede", "value": { "rev": "1-3c7653d06f7e049584bd5a4989fa74c8" } },
  { "id": "13ccc5598666c7a311837b1acc97ede7", "key": "13ccc5598666c7a311837b1acc97ede7", "value": { "rev": "1-2820d19e8b05653136f730c833ba5673" } },
  { "id": "154a9a71a0525d09aee52ef4a656686e", "key": "154a9a71a0525d09aee52ef4a656686e", "value": { "rev": "1-85f6f239cb778dfd03c1693544dcb6a7" } },
  { "id": "154a9a71a0525d09aee52ef4a657c904", "key": "154a9a71a0525d09aee52ef4a657c904", "value": { "rev": "1-cccedf2907fdcd1ee9c638b567a25eb8" } },
  { "id": "154a9a71a0525d09aee52ef4a6590491", "key": "154a9a71a0525d09aee52ef4a6590491", "value": { "rev": "1-fa8d34fdc52684cefe3fce51540052e2d" } },
  { "id": "154a9a71a0525d09aee52ef4a65a622a", "key": "154a9a71a0525d09aee52ef4a65a622a", "value": { "rev": "1-0a23000f7fd1eca4cc81ab7f0d0c2ca3" } },
  { "id": "154a9a71a0525d09aee52ef4a65b5ff6", "key": "154a9a71a0525d09aee52ef4a65b5ff6", "value": { "rev": "1-1ebac2a7456e274983218e1fd689cdfdc" } },
  { "id": "154a9a71a0525d09aee52ef4a65c7d55", "key": "154a9a71a0525d09aee52ef4a65c7d55", "value": { "rev": "1-58ba064c4b80edd513a19e5b036fbaf2" } },
  { "id": "154a9a71a0525d09aee52ef4a65db6be", "key": "154a9a71a0525d09aee52ef4a65db6be", "value": { "rev": "1-406163a5a1043f7ef3ee11f60e6ba255" } },
  { "id": "154a9a71a0525d09aee52ef4a6616504", "key": "154a9a71a0525d09aee52ef4a6616504", "value": { "rev": "1-61fcbb3266035487e882616122ed5eee" } },
  { "id": "154a9a71a0525d09aee52ef4a6629416", "key": "154a9a71a0525d09aee52ef4a6629416", "value": { "rev": "1-d53c8658e7d9c9397ac44706cd23dd0e" } },
  { "id": "154a9a71a0525d09aee52ef4a6637efd", "key": "154a9a71a0525d09aee52ef4a6637efd", "value": { "rev": "1-7af49213ff4d1a4f70b2845b3057a742" } },
  { "id": "154a9a71a0525d09aee52ef4a6647cdd", "key": "154a9a71a0525d09aee52ef4a6647cdd", "value": { "rev": "1-67c3f287a2f7b9b430fab01111b6754" } },
  { "id": "154a9a71a0525d09aee52ef4a665ac7c", "key": "154a9a71a0525d09aee52ef4a665ac7c", "value": { "rev": "1-5278bdf2ae6ca3e28c2499b2a87bcebb" } },
  { "id": "154a9a71a0525d09aee52ef4a6669b63", "key": "154a9a71a0525d09aee52ef4a6669b63", "value": { "rev": "1-20d6eb4c3eddl1ff2a9c772d573a632" } },
  { "id": "154a9a71a0525d09aee52ef4a667ab3a", "key": "154a9a71a0525d09aee52ef4a667ab3a", "value": { "rev": "1-8179d77f656dec40a0905199e4a7fc3b" } },
  { "id": "154a9a71a0525d09aee52ef4a668921a", "key": "154a9a71a0525d09aee52ef4a668921a", "value": { "rev": "1-6caa46f9fdfe1bec46bea06056f79cea" } },
  { "id": "154a9a71a0525d09aee52ef4a669be5e", "key": "154a9a71a0525d09aee52ef4a669be5e", "value": { "rev": "1-4010d0e7ea3dbbcfa5425001760955cb" } },
  { "id": "154a9a71a0525d09aee52ef4a66a9dc3", "key": "154a9a71a0525d09aee52ef4a66a9dc3", "value": { "rev": "1-c2fd0b635424cc507629b9034e2f4443" } },
  { "id": "154a9a71a0525d09aee52ef4a66bb08a", "key": "154a9a71a0525d09aee52ef4a66bb08a", "value": { "rev": "1-a221a2602071316705cb5df277c20aa0" } },
  { "id": "154a9a71a0525d09aee52ef4a66cefec", "key": "154a9a71a0525d09aee52ef4a66cefec", "value": { "rev": "1-5dc256f8f26f91b9459fe7769eeddd5b" } },
  { "id": "154a9a71a0525d09aee52ef4a66ec111", "key": "154a9a71a0525d09aee52ef4a66ec111", "value": { "rev": "1-535f5de1241af24851615a35172c3b80" } },
  { "id": "154a9a71a0525d09aee52ef4a66ff532", "key": "154a9a71a0525d09aee52ef4a66ff532", "value": { "rev": "1-21d31e1ab40a68368b9d6838e78e8f61" } },
  { "id": "154a9a71a0525d09aee52ef4a670c428", "key": "154a9a71a0525d09aee52ef4a670c428", "value": { "rev": "1-15a81adb4ed8b1e5c74ad0562e5e6d58" } },
  { "id": "154a9a71a0525d09aee52ef4a671d7da", "key": "154a9a71a0525d09aee52ef4a671d7da", "value": { "rev": "1-9d5f2bc2c91ec240343f9ef9c956a053" } },
  { "id": "154a9a71a0525d09aee52ef4a6731dc5", "key": "154a9a71a0525d09aee52ef4a6731dc5", "value": { "rev": "1-af954cf810eb834ee6e8f2f50c649150" } },
  { "id": "154a9a71a0525d09aee52ef4a67468b4", "key": "154a9a71a0525d09aee52ef4a67468b4", "value": { "rev": "1-c99bac80b3da3663db34516babf2b586" } },
  { "id": "154a9a71a0525d09aee52ef4a675f664", "key": "154a9a71a0525d09aee52ef4a675f664", "value": { "rev": "1-8d15c829ad4fc419f12480d5092c6679" } },
  { "id": "154a9a71a0525d09aee52ef4a676d348", "key": "154a9a71a0525d09aee52ef4a676d348", "value": { "rev": "1-94919024201607339c06d021177077ce" } },
  { "id": "154a9a71a0525d09aee52ef4a677a38c", "key": "154a9a71a0525d09aee52ef4a677a38c", "value": { "rev": "1-35ce9b738921db4b40b1cb2ff11dc0d6" } },
  { "id": "154a9a71a0525d09aee52ef4a6790076", "key": "154a9a71a0525d09aee52ef4a6790076", "value": { "rev": "1-43f635d524a39216b012e4eef3e3bb15" } }
]
```

```
{
  total_rows: 678,
  offset: 0,
- rows: [
  - {
    id: "0c8b4d6cefc1123854429a9f0f2d6dd6",
    key: "0c8b4d6cefc1123854429a9f0f2d6dd6",
  - value: {
      rev: "2-f2261c5bc9f640188416bb1511d0faa9"
    }
  },
  - {
    id: "0c8b4d6cefc1123854429a9f0f3fb4db",
    key: "0c8b4d6cefc1123854429a9f0f3fb4db",
  - value: {
      rev: "1-f86b1553cdaeb859ae5ead24895abf3c"
    }
  },
  - {
    id: "0c8b4d6cefc1123854429a9f0f65dab5",
    key: "0c8b4d6cefc1123854429a9f0f65dab5",
  - value: {
      rev: "1-5e2f59b8c82e6e28aa93d3aceb393df0"
```



# We can improve



**We can improve  
the usability of messages**

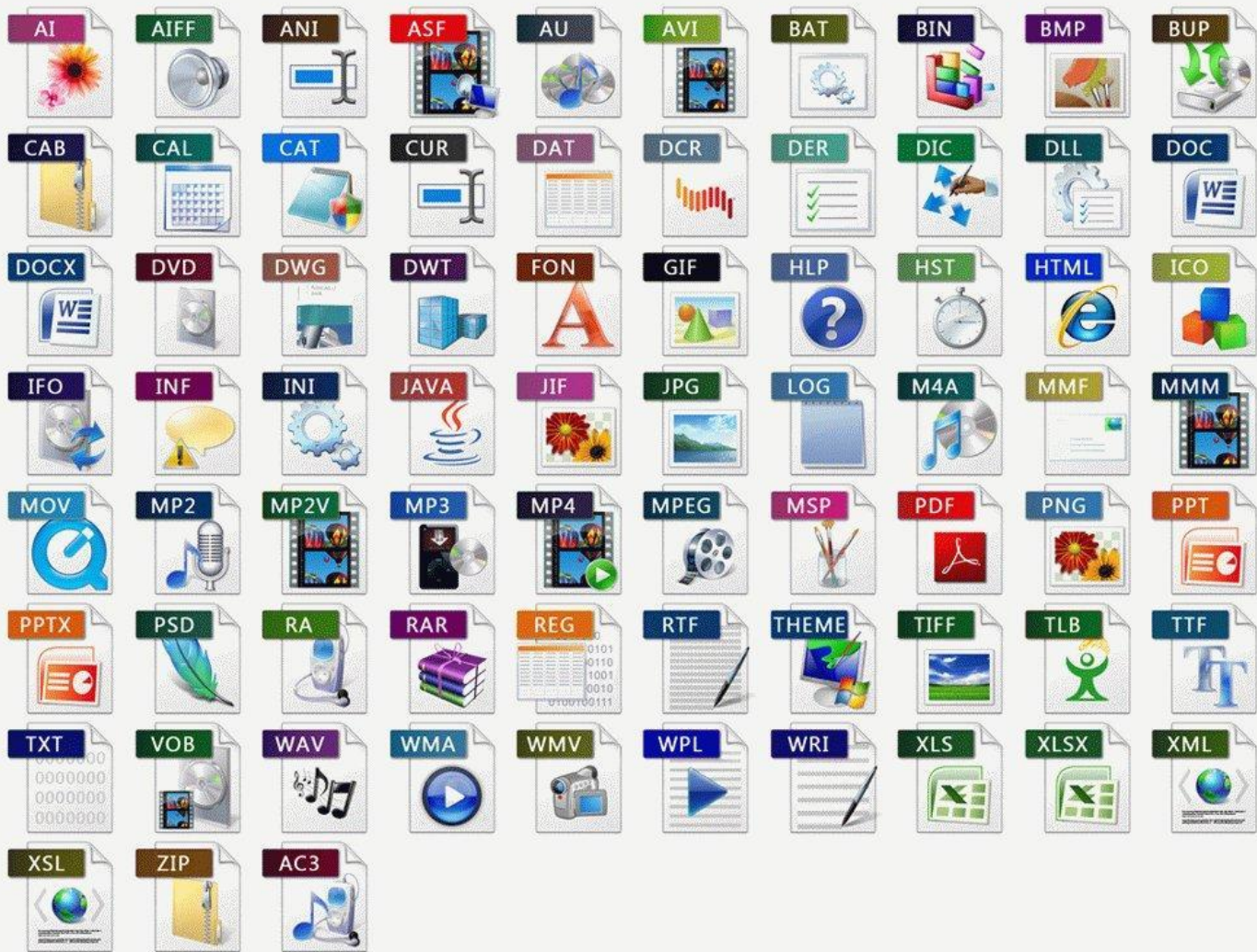


**There are three ways to  
do that...**



# 1. Format







**application/json**  
**adds very little affordance**



```
{"message": "Hello, there!", "id": "7416349041741341", "date": "2014-05-28T02:17:25.362Z"}
```



**collection+json  
adds quite a bit  
of affordance**



```
{
  "collection" :
  {
    "version" : "1.0",
    "href" : "http://localhost:1337/api/",

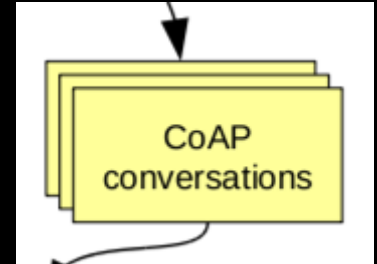
    "items" :
    [{
      "href": "http://localhost:1337/api/5266722824890167",
      "data": [
        {
          "name": "text",
          "value": "tasting"
        },
        {
          "name": "date_posted",
          "value": "2013-01-09T15:58:22.674z"
        }
      ]
    }
  ],

  "template" : {
    "data" : [
      {
        "prompt" : "Text of message",
        "name" : "text",
        "value" : ""
      }
    ]
  }
}
```



# 2. Protocol





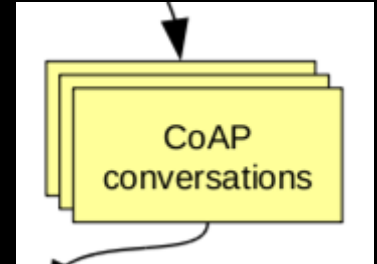
for the  
**action**

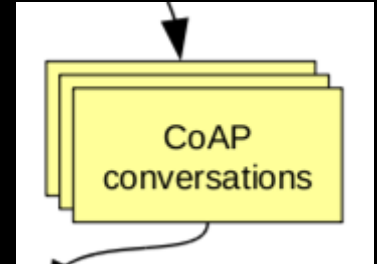
his new



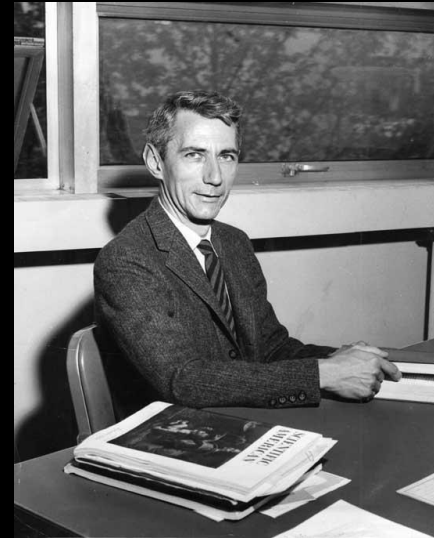








So far, we're still in  
"Shannon-land"



# 3. Semantics



**On the web,  
the "internal model"  
is represented by  
Semantics**



```
{
  "collection" :
  {
    "version" : "1.0",
    "href" : "http://localhost:1337/api/",
    "items" :
    [{
      "href": "http://localhost:1337/api/5266722824890167",
      "data": [
        {
          "name": "text",
          "value": "tasting"
        },
        {
          "name": "date_posted",
          "value": "2013-01-09T15:58:22.674Z"
        }
      ]
    }
  ]
},
  "template" : {
    "data" : [
      {
        "prompt" : "Text of message",
        "name" : "text",
        "value" : ""
      }
    ]
  }
}
```



Relation Name <small>✕</small>	Description <small>✕</small>	Reference <small>✕</small>
about	Refers to a resource that is the subject of the link's context.	[RFC6903], section 2
alternate	Refers to a substitute for this context	[http://www.w3.org/TR/html5/links.html#link-type-alternate]
appendix	Refers to an appendix.	[http://www.w3.org/TR/1999/REC-html401-19991224]
archives	Refers to a collection of records, documents, or other materials of historical interest.	[http://www.w3.org/TR/2011/WD-html5-20110113/links.html#rel-archives]
author	Refers to the context's author.	[http://www.w3.org/TR/html5/links.html#link-type-author]
bookmark	Gives a permanent link to use for bookmarking purposes.	[http://www.w3.org/TR/html5/links.html#link-type-bookmark]
canonical	Designates the preferred version of a resource (the IRI and its contents).	[RFC6596]
chapter	Refers to a chapter in a collection of resources.	[http://www.w3.org/TR/1999/REC-html401-19991224]
collection	The target IRI points to a resource which represents the collection resource for the context IRI.	[RFC6573]
contents	Refers to a table of contents.	[http://www.w3.org/TR/1999/REC-html401-19991224]
copyright	Refers to a copyright statement that applies to the link's context.	[http://www.w3.org/TR/1999/REC-html401-19991224]
create-form	The target IRI points to a resource where a submission form can be obtained.	[RFC6861]
current	Refers to a resource containing the most recent item(s) in a collection of resources.	[RFC5005]
describedby	Refers to a resource providing information about the link's context.	[http://www.w3.org/TR/powder-dr/#assoc-linking]
describes	The relationship A 'describes' B asserts that resource A provides a description of resource B. There are no constraints on the format or representation of either A or B, neither are there any further constraints on either resource.	[RFC6892]



Relation Name <small>⌵</small>	Description <small>⌵</small>	Reference <small>⌵</small>
about	Refers to a resource that is the subject of the link's context.	[RFC6903], section 2
alternate	Refers to a substitute for this context	[http://www.w3.org/TR/html5/links.html#link-type-alternate]
appendix	Refers to an appendix.	[http://www.w3.org/TR/1999/REC-html401-19991224]
archives	Refers to a collection of records, documents, or other materials of historical interest.	[http://www.w3.org/TR/2011/WD-html5-20110113/links.html#rel-archives]
author	Refers to the context's author.	[http://www.w3.org/TR/html5/links.html#link-type-author]
bookmark	Gives a permanent link to use for bookmarking purposes.	[http://www.w3.org/TR/html5/links.html#link-type-bookmark]
canonical	Designates the preferred version of a resource (the IRI and its contents).	[RFC6596]
chapter	Refers to a chapter in a collection of resources.	[http://www.w3.org/TR/1999/REC-html401-19991224]
collection	The target IRI points to a resource which represents the collection resource for the context IRI.	[RFC6573]
contents	Refers to a table of contents.	[http://www.w3.org/TR/1999/REC-html401-19991224]
copyright	Refers to a copyright statement that applies to the link's context.	[http://www.w3.org/TR/1999/REC-html401-19991224]
create-form	The target IRI points to a resource where a submission form can be obtained.	[RFC6861]
current	Refers to a resource containing the most recent item(s) in a collection of resources.	[RFC5005]
describedby	Refers to a resource providing information about the link's context.	[http://www.w3.org/TR/powder-dr/#assoc-linking]
describes	The relationship A 'describes' B asserts that resource A provides a description of resource B. There are no constraints on the format or representation of either A or B, neither are there any further constraints on either resource.	[RFC6892]

Property	Expected Type	Description
<b>Properties from <u>Thing</u></b>		
<u>additionalType</u>	URL	An additional type for the item, typically used for adding more is a relationship between something and a class that the thing is 'typeof' attribute - for multiple types. Schema.org tools may have defined externally.
<u>alternateName</u>	Text	An alias for the item.
<u>description</u>	Text	A short description of the item.
<u>image</u>	URL	URL of an image of the item.
<u>name</u>	Text	The name of the item.
<u>potentialAction</u>	Action	Indicates a potential Action, which describes an idealized action
<u>sameAs</u>	URL	URL of a reference Web page that unambiguously indicates the page, or official website.
<u>url</u>	URL	URL of the item.





Relation Name	Description	Reference
about	Refers to a resource that is the subject of the link's context.	[RFC6903], section 2
alternate	Refers to a substitute for this context	[http://www.w3.org/TR/html5/links.html#link-type-alternate]
appendix	Refers to an appendix.	[http://www.w3.org/TR/1999/REC-html401-19991224]
archives	Refers to a collection of records, documents, or other materials of historical interest.	[http://www.w3.org/TR/2011/WD-html5-20110113/links.html#rel-archives]
author	Refers to the context's author.	[http://www.w3.org/TR/html5/links.html#link-type-author]
bookmark	Gives a permanent link to use for bookmarking purposes.	[http://www.w3.org/TR/html5/links.html#link-type-bookmark]
canonical	Designates the preferred version of a resource (the IRI and its contents).	[RFC6596]
chapter	Refers to a chapter in a collection of resources.	[http://www.w3.org/TR/1999/REC-html401-19991224]
collection	The target IRI points to a resource which represents the collection resource for the context IRI.	[RFC6573]
contents	Refers to a table of contents.	[http://www.w3.org/TR/1999/REC-html401-19991224]
copyright	Refers to a copyright statement that applies to the link's context.	[http://www.w3.org/TR/1999/REC-html401-19991224]
create-form	The target IRI points to a resource where a submission form can be obtained.	[RFC6861]
current	Refers to a resource containing the most recent item(s) in a collection of resources.	[RFC5005]
describedby	Refers to a resource providing information about the link's	[http://www.w3.org/TR/powder-dr/#assoc-linking]

Term Name: contributor
URI: <a href="http://purl.org/dc/elements/1.1/contributor">http://purl.org/dc/elements/1.1/contributor</a>
Label: Contributor
Definition: An entity responsible for making contributions to the resource.
Comment: Examples of a Contributor include a person, an organization, or a service. Typically, the

Comment: Examples of a Contributor include a person, an organization, or a service. Typically, the
--

Term Name: coverage
---------------------

URI: <a href="http://purl.org/dc/elements/1.1/coverage">http://purl.org/dc/elements/1.1/coverage</a>
Label: Coverage

Definition: The spatial or temporal topic of the resource, the spatial applicability of the resource
--

Comment: Spatial topic and spatial applicability may be a named place or a location specified by a range. A jurisdiction may be a named administrative entity or a geographic place in a vocabulary such as the Thesaurus of Geographic Names [TGN]. Where appropriate, references may be made to as sets of coordinates or date ranges.
--

References: [TGN] <a href="http://www.getty.edu/research/tools/vocabulary/tgn/index.html">http://www.getty.edu/research/tools/vocabulary/tgn/index.html</a>
---

Term Name: creator
--------------------

URI: <a href="http://purl.org/dc/elements/1.1/creator">http://purl.org/dc/elements/1.1/creator</a>
Label: Creator

Definition: An entity primarily responsible for making the resource.
--

Comment: Examples of a Creator include a person, an organization, or a service. Typically, the
--

Term Name: date
-----------------

Property	Expected Type	Description
<b>Properties from Thing</b>		
<a href="#">additionalType</a>	URL	An additional type for the item, typically used for adding more specific types. It is a relationship between something and a class that the thing is an instance of. Schema.org tools may have defined this property externally.
<a href="#">alternateName</a>	Text	An alias for the item.
<a href="#">description</a>	Text	A short description of the item.
<a href="#">image</a>	URL	URL of an image of the item.
<a href="#">name</a>	Text	The name of the item.
<a href="#">potentialAction</a>	Action	Indicates a potential Action, which describes an idealized action that can be performed on the item.
<a href="#">sameAs</a>	URL	URL of a reference Web page that unambiguously indicates the item's identity, e.g., the item's official page, or official website.
<a href="#">url</a>	URL	URL of the item.



Relation Name	Description	Reference
about	Refers to a resource that is the subject of the link's context.	[RFC6903], section 2
alternate	Refers to a substitute for this context	[http://www.w3.org/TR/html5/links.html#link-type-alternate]
appendix	Refers to an appendix.	[http://www.w3.org/TR/1999/REC-html401-19991224]
archives	Refers to a collection of records, documents, or other materials of historical interest.	[http://www.w3.org/TR/2011/WD-html5-20110113/links.html#rel-archives]
author	Refers to the context's author.	[http://www.w3.org/TR/html5/links.html#link-type-author]
bookmark	Gives a permanent link to use for bookmarking purposes.	[http://www.w3.org/TR/html5/links.html#link-type-bookmark]
canonical	Designates the preferred version of a resource (the IRI and its contents).	[RFC6596]
chapter	Refers to a chapter in a collection of resources.	[http://www.w3.org/TR/1999/REC-html401-19991224]
collection	The target IRI points to a resource which represents the collection resource for the context IRI.	[RFC6573]
contents	Refers to a table of contents.	[http://www.w3.org/TR/1999/REC-html401-19991224]
copyright	Refers to a copyright statement that applies to the link's context.	[http://www.w3.org/TR/1999/REC-html401-19991224]
create-form	The target IRI points to a resource where a submission form can be obtained.	[RFC6861]
current	Refers to a resource containing the most recent item(s) in a collection of resources.	[RFC5005]
describedby	Refers to a resource providing information about the link's	[http://www.w3.org/TR/powder-dr/#assoc-linking]

Term Name: contributor
URI: <a href="http://purl.org/dc/elements/1.1/contributor">http://purl.org/dc/elements/1.1/contributor</a>
Label: Contributor
Definition: An entity responsible for making contributions to the resource.
Comment: Examples of a Contributor include a person, an organization, or a service. Typically,

Comment: Examples of a Contributor include a person, an organization, or a service. Typically,
--

Term Name: coverage
---------------------

URI: <a href="http://purl.org/dc/elements/1.1/coverage">http://purl.org/dc/elements/1.1/coverage</a>
--

Label: Coverage
-----------------

Definition: The spatial or temporal topic of the resource, the spatial applicability of the resource
--

Comment: Spatial topic and spatial applicability may be a named place or a location specified by a range. A jurisdiction may be a named administrative entity or a geographic place by a vocabulary such as the Thesaurus of Geographic Names [TGN]. Where appropriate, ranges may be specified as sets of coordinates or date ranges.
--

References: [TGN] <a href="http://www.getty.edu/research/tools/vocabulary/tgn/index.html">http://www.getty.edu/research/tools/vocabulary/tgn/index.html</a>
---

Term Name: creator
--------------------

URI: <a href="http://purl.org/dc/elements/1.1/creator">http://purl.org/dc/elements/1.1/creator</a>
--

Label: Creator
----------------

Definition: An entity primarily responsible for making the resource.
--

Comment: Examples of a Creator include a person, an organization, or a service. Typically, the
--

Term Name: date
-----------------

Keyword	Effect on link	Effect on a, area	Brief description (from the relevant specification where possible)
acquaintance	not allowed	external relation	the person represented by the current document considers the person represented by the referenced document to be an acquaintance
alternate	external resource	external relation	Designates substitute versions for the document in which the link occurs. When used together with the lang attribute, it implies a translated version of the document. When used together with the media attribute, it implies a version designed for a different medium (or media).
appendix	allowed	allowed	Refers to a document serving as an appendix in a collection of documents.
bookmark	not allowed	allowed	Refers to a bookmark. A bookmark is a link to a key entry point within an extended document. The title attribute may be used, for example, to label the bookmark. Note that several bookmarks may be defined in each document.
chapter	allowed	allowed	Refers to a document serving as a chapter in a collection of documents.
child	not allowed	external relation	the referenced person is a child of the person represented by the current document
colleague	not allowed	external relation	the referenced person is a colleague of the person represented by the current document
contact	not allowed	external relation	the person represented by the current document considers the person represented by the referenced document to be a contact
contents	allowed	allowed	Refers to a document serving as a table of contents. Some user agents also support the synonym ToC (from "Table of Contents").
copyright	allowed	allowed	Refers to a copyright statement for the current document.

additionalType	URL	An additional type for the item, typically used for adding more types. It is a relationship between something and a class that the thing is a member of - for multiple types. Schema.org tools may have been defined externally.
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alternateName	Text	An alias for the item.
---------------	------	------------------------

description	Text	A short description of the item.
-------------	------	----------------------------------

image	URL	URL of an image of the item.
-------	-----	------------------------------

name	Text	The name of the item.
------	------	-----------------------

potentialAction	Action	Indicates a potential Action, which describes an idealized action that the item can perform.
-----------------	--------	--

sameAs	URL	URL of a reference Web page that unambiguously indicates the item's identity, e.g., the item's official page, or official website.
--------	-----	--

url	URL	URL of the item.
-----	-----	------------------



Relation Name	Description	Reference
about	Refers to a resource that is the subject of the link's context.	[RFC6903], section 2
alternate	Refers to a substitute for this context	[http://www.w3.org/TR/html5/links.html#link-type-alternate]
appendix	Refers to an appendix.	[http://www.w3.org/TR/1999/REC-html401-19991224]
archives	Refers to a collection of records, documents, or other materials of historical interest.	[http://www.w3.org/TR/2011/WD-html5-20110113/links.html#rel-archives]
author	Refers to the context's author.	[http://www.w3.org/TR/html5/links.html#link-type-author]
bookmark	Gives a permanent link to use for bookmarking purposes.	[http://www.w3.org/TR/html5/links.html#link-type-bookmark]
canonical	Designates the preferred version of a resource (the IRI and its contents).	[RFC6596]
chapter	Refers to a chapter in a collection of resources.	[http://www.w3.org/
collection	The target IRI points to a resource which represents the collection resource for the context IRI.	[RFC6573]
contents	Refers to a table of contents.	[http://www.w3.org/
copyright	Refers to a copyright statement that applies to the link's context.	[http://www.w3.org/
create-form	The target IRI points to a resource where a submission form can be obtained.	[RFC6861]
current	Refers to a resource containing the most recent item(s) in a collection of resources.	[RFC5005]
describedby	Refers to a resource providing information about the link's	[http://www.w3.org/

describes	<b>Term Name: contributor</b>	
	URI:	<a href="http://purl.org/dc/elements/1.1/contributor">http://purl.org/dc/elements/1.1/contributor</a>
	Label:	Contributor
	Definition:	An entity responsible for making contributions to the resource.
	Comment:	Examples of a Contributor include a person, an organization, or a s
	<b>Term Name: coverage</b>	
	URI:	<a href="http://purl.org/dc/elements/1.1/coverage">http://purl.org/dc/elements/1.1/coverage</a>
	Label:	Coverage
	Definition:	The spatial or temporal topic of the resource, the spatial applicabil
	Comment:	Spatial topic and spatial applicability may be a named place or a location specified by range. A jurisdiction may be a named administrative entity or a geographic place in a vocabulary such as the Thesaurus of Geographic Names [TGN]. Where appropriate, r as sets of coordinates or date ranges.
	References:	[TGN] <a href="http://www.getty.edu/research/tools/vocabulary/tgn/index.html">http://www.getty.edu/research/tools/vocabulary/tgn/index.html</a>
	<b>Term Name: creator</b>	
	URI:	<a href="http://purl.org/dc/elements/1.1/creator">http://purl.org/dc/elements/1.1/creator</a>
	Label:	Creator
	Definition:	An entity primarily responsible for making the resource.
	Comment:	Examples of a Creator include a person, an organization, or a service. Typically, the
	<b>Term Name: date</b>	

Keyword	Effect on link	Effect on a, area	Brief description (from the relevant specification where possible)	
acquaintance	not allowed	external relation	the person represented by the current document considers the person represented by the referenced document to be an acquaintance	
alternate	external resource	external relation	Designates substitute versions for the document in which the link occurs. When used together with the lang attribute, it implies a translated version of the document. When used together with the media attribute, it implies a version designed for a different medium (or media).	
		wed	allowed	Refers to a document serving as an appendix in a collection of documents.
		wed	allowed	Refers to a bookmark. A bookmark is a link to a key entry point within an extended document. The title attribute may be used, for example, to label the bookmark. Note that several bookmarks may be defined in each document.
		wed	allowed	Refers to a document serving as a chapter in a collection of documents.
		wed	external relation	the referenced person is a child of the person represented by the current document
		wed	external relation	the referenced person is a colleague of the person represented by the current document
		wed	external relation	the person represented by the current document considers the person represented by the referenced document to be a contact
		wed	allowed	Refers to a document serving as a table of contents. Some user agents also support the synonym ToC from "Table of Contents".
		wed	allowed	Refers to a copyright statement for the current document.

URL	Text	An additional type for the item, typically used for adding more s is a relationship between something and a class that the thing is 'typeof' attribute - for multiple types. Schema.org tools may have defined externally.
alternateName	Text	An alias for the item.
description	Text	A short description of the item.
image	URL	URL of an image of the item.
name	Text	The name of the item.
potentialAction	Action	Indicates a potential Action, which describes an idealized action
sameAs	URL	URL of a reference Web page that unambiguously indicates the i page, or official website.
url	URL	URL of the item.



# Modeling Information

- Represent Data in Rich Formats
- Support Multiple Protocols
- Separate Semantics from Format & Protocol



Afterglow Light Pattern  
380,000 yrs.

Dark Ages

Development of  
Galaxies, Planets, etc.

Dark Energy  
Accelerated Expansion

Inflation

Quantum  
uctuations

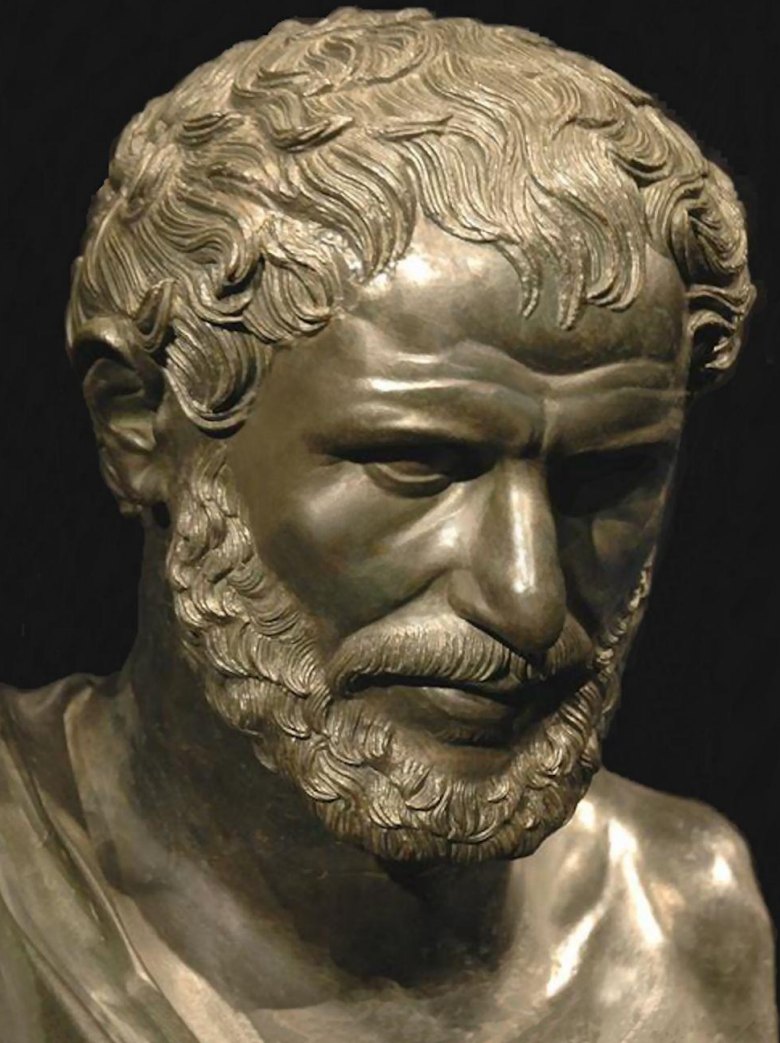
1st Stars  
about 400 million yrs.

# Ravages of Time

Big Bang Expansion

13.7 billion years





“Everything changes  
and nothing stands  
still.”

**Heraclitus, 402 (quoted)**

# Mother Tongues

Tracing the roots of computer languages through the ages

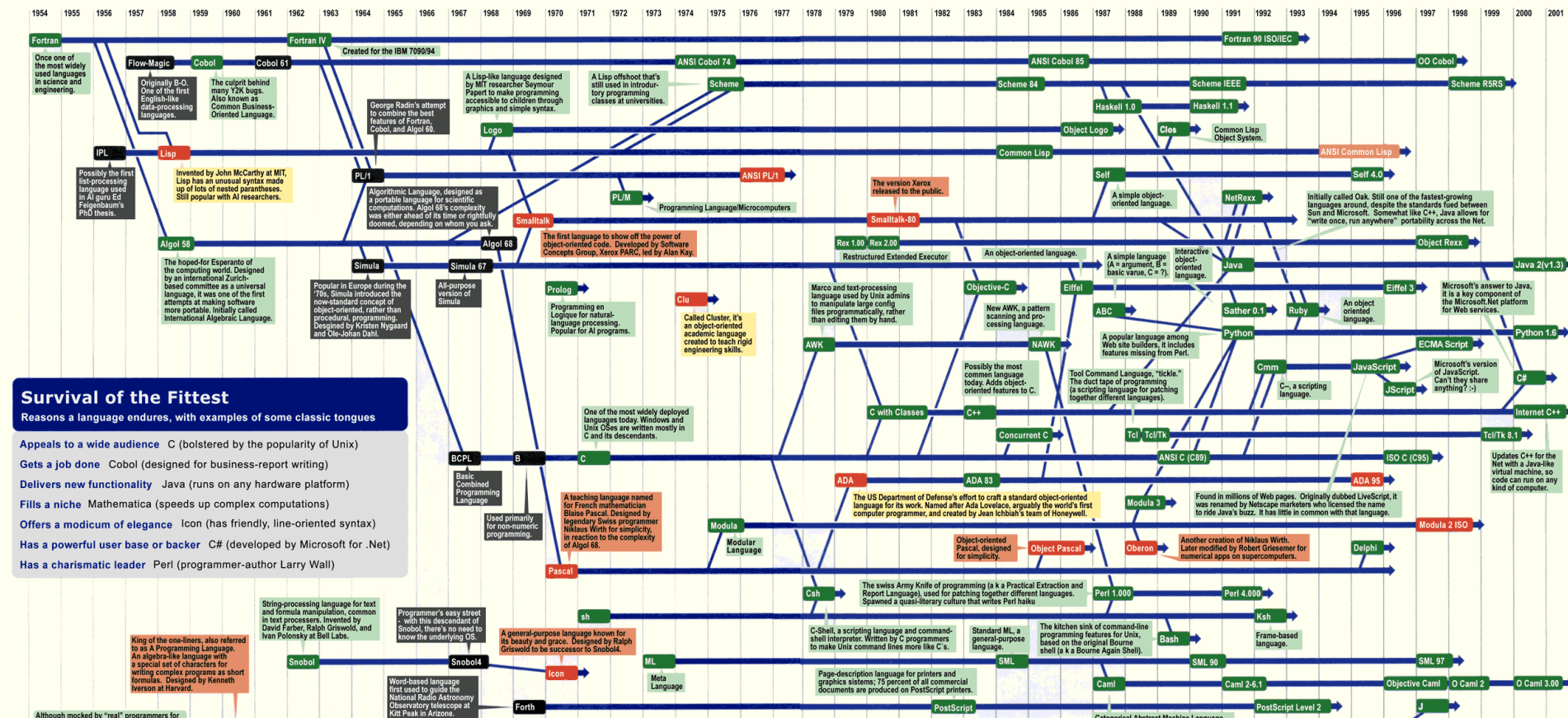
Just like half of the world's spoken tongues, most of the 2,300-plus computer programming languages are either endangered or extinct. As powerhouses C/C++, Visual Basic, Cobol, Java and other modern source codes dominate our systems, hundreds of older languages are running out of life.

An ad hoc collection of engineers-electronic lexicographers, if you will-aim to save, or at least document the lingo of classic software. They're combing the globe's 9 million developers in search of coders still fluent in these nearly forgotten lingua frangas. Among the most endangered are Ada, APL, B (the predecessor of C), Lsp, Oberon, Smalltalk, and Simula.

Code-raker Grady Booch, Rational Software's chief scientist, is working with the Computer History Museum in Silicon Beach, to record and, in some cases, maintain languages by writing new compilers so our ever-changing hardware can grok the code. Why bother? "They tell us about the state of software practice, the minds of their inventors, and the technical, social, and economic forces that shaped history at the time," Booch explains. "They'll provide the raw material for software archaeologists, historians, and developers to learn what worked, what was brilliant, and what was an utter failure." Here's a peek at the strongest branches of programming's family tree. For a nearly exhaustive rundown, check out the Language List at [HTTP://www.informatik.uni-freiburg.de/Java/misc/lang\\_list.html](http://www.informatik.uni-freiburg.de/Java/misc/lang_list.html). - Michael Mendeno

**Key**

- 1954 Year Introduced
- Active: thousands of users
- Protected: taught at universities; compilers available
- Endangered: usage dropping off
- Extinct: no known active users or up-to-date compilers
- Lineage continues



## Survival of the Fittest

Reasons a language endures, with examples of some classic tongues

- Appeals to a wide audience C (bolstered by the popularity of Unix)
- Gets a job done Cobol (designed for business-report writing)
- Delivers new functionality Java (runs on any hardware platform)
- Fills a niche Mathematica (speeds up complex computations)
- Offers a modicum of elegance Icon (has friendly, line-oriented syntax)
- Has a powerful user base or backer C# (developed by Microsoft for .Net)
- Has a charismatic leader Perl (programmer-author Larry Wall)

String-processing language for text and formula manipulation, common in text processors. Invented by David Farber, Ralph Griswold, and Ivan Polonsky at Bell Labs.

Programmer's easy street - with this descendant of Snobol, there's no need to know the underlying OS.

A general-purpose language known for its beauty and grace. Designed by Ralph Griswold to be successor to Snobol.

Word-based language first used to guide the National Radio Astronomy Observatory telescope at Kitt Peak in Arizona.

King of the one-liners, also referred to as A Programming Language. An algebra-like language with a special set of characters for writing complex programs as short formulas. Designed by Kenneth Thompson at Harvard.

Although mocked by "real" programmers for



PAPER

PUNCH  
CARDS

DRUM  
MEMORY

MAGNETIC  
TAPE

HARD  
DRIVE

FLOPPY  
DISK

COMPACT  
DISC

COMPACT  
FLASH

ZIP  
DRIVE

DVD

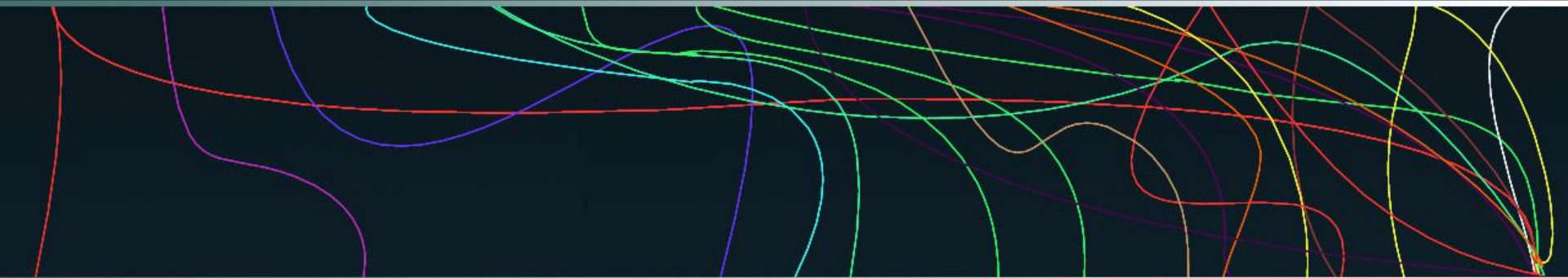
SECURE  
DIGITAL

USB FLASH  
DRIVE

PORTABLE  
HARD DRIVE

BLU-RAY

DNA  
STORAGE



200 BC

1725

1932

1951

1956

1971

1978

1990

1994

1995

1999

2000

2006

PRESENT







**Microsoft Windows 95**

**Boot Disk**  
Windows Series  
Disk format: High-density (DMF)  
Microsoft recommends virus checking before running setup

**Setup Instructions:**  
If you do not have MS-DOS on your computer:  
1. Turn off your computer.  
2. Insert the Boot Disk in drive A.  
3. Turn on your computer.

© 1991-1995 Microsoft Corporation. All rights reserved.

**Microsoft Windows 95**

For installation only with a new PC

**Setup Boot Disk**  
Windows Series  
Disk format: High-density (DMF)  
Microsoft recommends virus checking before running setup

**Setup Instructions:**  
1. At the MS-DOS prompt, type  
2. Turn off your computer.  
3. Turn on your computer.

© 1991-1995 Microsoft Corporation. All rights reserved.

**Microsoft Windows 95**

For installation only with a new PC

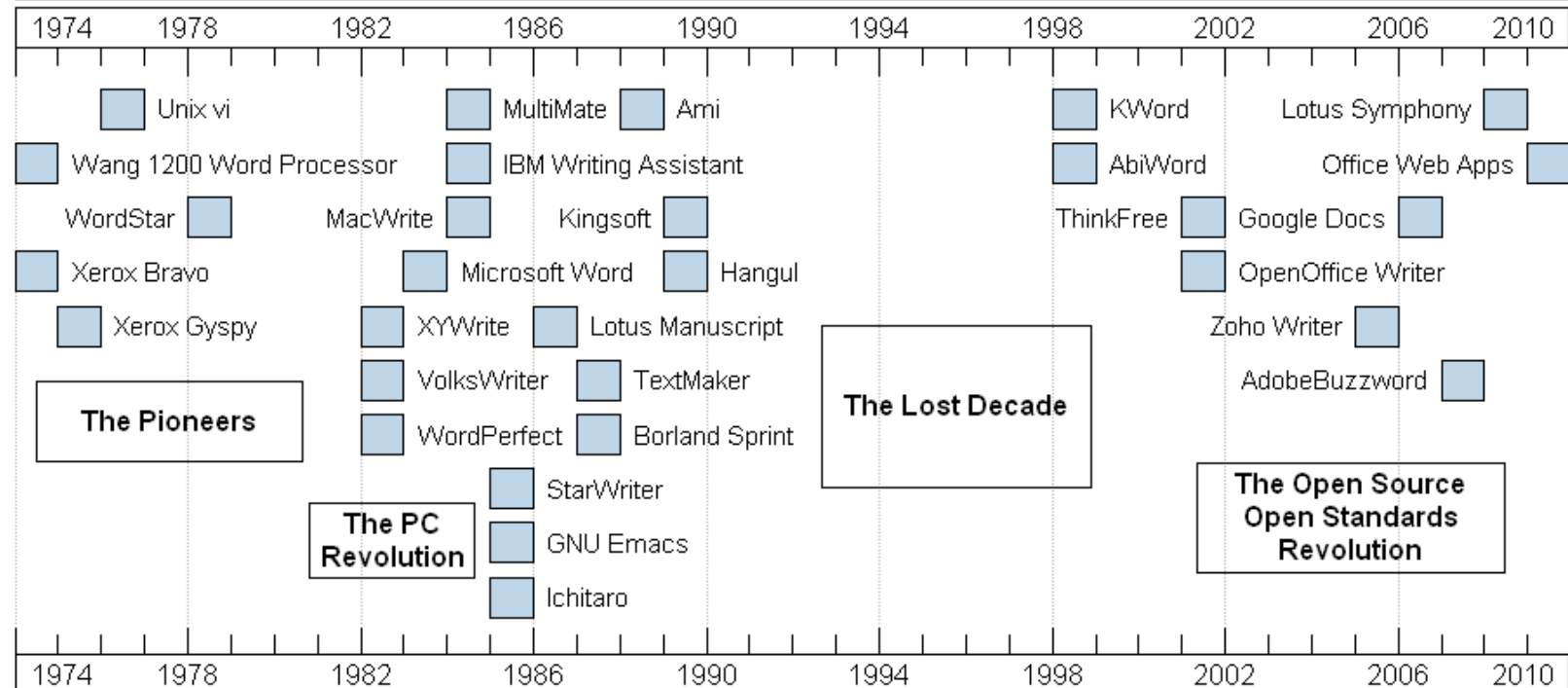
**Microsoft Setup Disks**  
Setup Boot Disk  
Windows Series  
Disk format: High-density (1.44 MB)

**Setup Instructions:**  
1. Turn off your computer.  
2. Insert the Setup Boot Disk in drive A.  
3. Turn on your computer.

© 1991-1995 Microsoft Corporation. All rights reserved.



# Word Processors

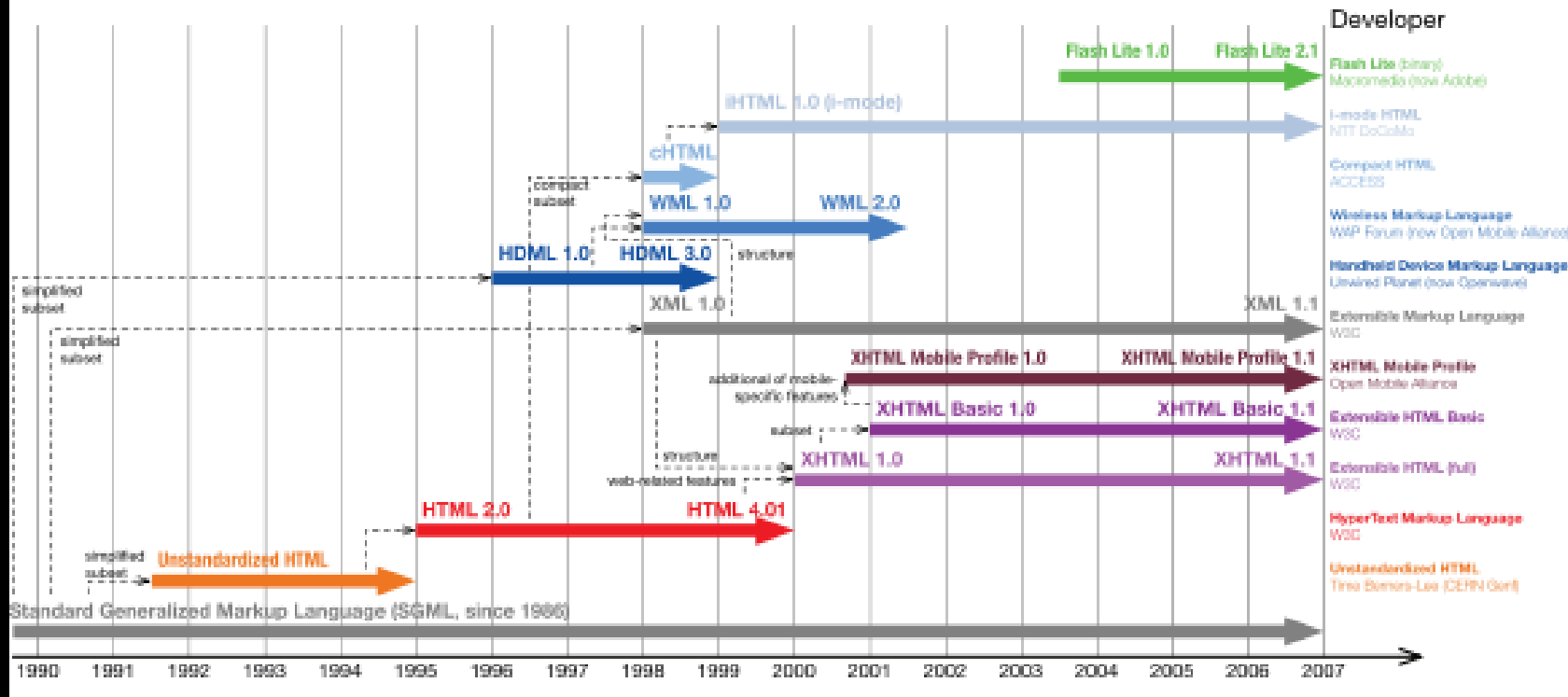


**The Pioneers**

**The PC  
Revolution**

**The Lost Decade**

**The Open Source  
Open Standards  
Revolution**



Internet Engineering Task Force (IETF)

Request for Comments: 7230

Obsoletes: 2145, 2616

Updates: 2817, 2818

Category: Standards Track

ISSN: 2070-1721

R. Fielding, Ed.

Adobe

J. Reschke, Ed.

greenbytes

June 2014

## Hypertext Transfer Protocol (HTTP/1.1): Message Syntax and Routing

### Abstract

The Hypertext Transfer Protocol (HTTP) is a stateless application-level protocol for distributed, collaborative, hypertext information systems. This document provides an overview of HTTP architecture and its associated terminology, defines the "http" and "https" Uniform Resource Identifier (URI) schemes, defines the HTTP/1.1 message syntax and parsing requirements, and describes related security concerns for implementations.

### Status of This Memo

This is an Internet Standards Track document.

This document is a product of the Internet Engineering Task Force (IETF). It represents the consensus of the IETF community. It has received public review and has been approved for publication by the Internet Engineering Steering Group (IESG). Further information on Internet Standards is available in Section 2 of RFC 5741.

Information about the current status of this document, any errata,



# Storage Format



**Storage Format  
is not**



**Storage Format  
is not  
Transfer Format**



# CSV

```
EXCELDATA.CSV - Notepad
File Edit Format View Help
QNO;EARLY;LATE;SLNO;F/MAIL;IND1;IND2;IND3;IND4;IND5;SALES;EC1;EC2;EC3;ECS1;ECS2;ECS3;EC
1019;0;0;12;0;0;1;0;0;0;53;2;2;2;2;6;1;2;2;1;2;1;1;2;5;4;4;1;2;2;5;4;1;2;6;1;1;4;4;4;5;
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1040;0;0;14;0;0;1;0;0;0;1400;5;2;3;2;5;6;5;6;3;2;3;3;3;5;6;6;5;5;6;6;5;3;5;5;6;6;6;6;6;
1041;0;0;13;0;0;0;1;0;0;160;6;6;4;6;6;3;5;6;4;5;3;3;6;7;6;6;7;6;6;6;6;5;4;6;6;6;7;5;5;6;
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1192;0;1;39;0;0;1;0;0;0;86;6;2;1;2;7;1;3;2;2;2;2;2;4;4;5;6;3;6;6;6;3;2;5;6;2;4;3;3;2;5;
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2009;0;0;11;0;1;0;0;0;0;70;4;1;1;1;5;1;1;1;1;1;1;7;1;1;1;1;7;1;4;1;1;1;3;7;1;7;1;7;4;
2017;0;0;73;0;0;0;0;0;0;107;5;7;7;4;3;6;7;4;6;3;5;3;2;5;6;7;7;4;6;5;7;7;3;6;7;6;7;7;6;5;
2025;1;1;123;0;1;0;0;0;0;86;4;4;2;2;2;5;2;2;2;3;2;2;5;7;7;5;7;5;2;7;7;2;4;7;3;7;4;7;2;
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2031;0;0;7;0;0;0;0;0;0;15070;5;2;1;1;3;4;2;2;3;2;3;6;6;6;6;4;4;4;4;7;3;3;5;6;6;6;6;6;4;
2033;0;0;29;0;0;1;0;0;0;15070;4;5;5;2;4;2;2;3;1;2;1;2;3;6;5;2;4;4;6;6;3;3;4;6;3;3;7;6;5;
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2039;0;1;63;0;0;0;0;1;0;89;5;2;2;2;5;5;2;4;2;3;1;1;3;3;4;4;3;2;5;5;3;5;2;4;1;3;1;1;1;2;
2040;0;0;15;0;0;1;0;0;0;1400;6;5;1;2;3;6;2;2;1;5;1;1;6;6;6;6;6;6;6;2;6;6;6;6;6;6;6;6;
2041;0;0;3;0;0;0;1;0;0;160;5;1;1;4;4;5;2;1;2;1;1;7;4;6;6;4;4;5;5;3;3;3;6;1;4;4;2;6;4;
2046;0;1;62;0;1;0;0;0;0;98;4;1;3;1;1;5;7;1;1;2;4;2;2;2;3;4;2;3;4;2;3;4;2;6;5;2;4;6;6;4;6;4;2;
```





# XML

```
<?xml version="1.0" encoding="UTF-8"?>
- <IntraConsignment xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance" xmlns:common="http://www.minfin.fgov.be/InputCommon"
  xmlns="http://www.minfin.fgov.be/IntraConsignment" IntraListingsNbr="1">
  - <Representative>
    <common:RepresentativeID identificationType="NVAT" issuedBy="BE">0429262018</common:RepresentativeID>
    <common:Name>656 Belgium Demo</common:Name>
    <common:Street>Koningin Astridlaan 166</common:Street>
    <common:PostCode>1780</common:PostCode>
    <common:City>Wemmel</common:City>
    <common:CountryCode>BE</common:CountryCode>
    <common:EmailAddress>maldinho@deltabike.com</common:EmailAddress>
    <common:Phone>02321521</common:Phone>
  </Representative>
  - <IntraListing AmountSum="6226.42" ClientsNbr="1" SequenceNumber="1">
    - <Declarant>
      <common:VATNumber>0429262018</common:VATNumber>
      <common:Name>656 Belgium Demo</common:Name>
      <common:Street>Koningin Astridlaan 166</common:Street>
      <common:PostCode>1780</common:PostCode>
      <common:City>Wemmel</common:City>
      <common:CountryCode>BE</common:CountryCode>
    </Declarant>
    - <Period>
      <Month>11</Month>
      <Year>2011</Year>
    </Period>
    - <IntraClient SequenceNumber="1">
      <CompanyVATNumber issuedBy="BE">0404880077</CompanyVATNumber>
      <Code>L</Code>
      <Amount>6226.42</Amount>
    </IntraClient>
  </IntraListing>
</IntraConsignment>
```



# JSON

```
C:\Windows\system32\cmd.exe

C:\tidyjson>tidyjson example.txt
{
  "widget" : {
    "debug" : true,
    "window" : {
      "title" : "Sample Konfabulator widget",
      "name" : "main_window",
      "width" : 500,
      "height" : 500
    },
    "image" : {
      "src" : "Images/Sun.png",
      "name" : "sun1",
      "hOffset" : 250,
      "vOffset" : 250,
      "alignment" : "center"
    },
    "text" : {
      "data" : "Click Here",
      "size" : 36,
      "style" : "bold",
      "name" : "text1",
      "hOffset" : 250,
      "vOffset" : 100,
      "alignment" : "center"
    }
  }
}
```



# RDF (n3)

```
@prefix : <http://www.mygrid.org.uk/mygrid-moby-service#> .
@prefix rdf: <http://www.w3.org/1999/02/22-rdf-syntax-ns#> .
<http://sadiframework.org/examples/hello> a :serviceDescription;
    :hasOperation <http://sadiframework.org/examples/hello#operation>;
    :hasServiceDescriptionText "A simple Hello";
    :hasServiceNameText "Hello"^^<http://www.w3.org/2001/XMLSchema#string> .

<http://sadiframework.org/examples/hello#operation> a :operation;
    :inputParameter <http://sadiframework.org/examples/hello#input>;
    :outputParameter <http://sadiframework.org/examples/hello#output> .

<http://sadiframework.org/examples/hello#input> a :parameter;
    :objectType <http://sadiframework.org/examples/hello.owl#NamedIndividual> .

<http://sadiframework.org/examples/hello#output> a :parameter;
    :objectType <http://sadiframework.org/examples/hello.owl#GreetedIndividual> .
```



# Select a Storage Format



# Select a Storage Format

- CSV has no strong schema modeling
- XML and JSON both have schema tooling
- RDF-family offers built-in semantics



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- CSV has no strong schema modeling
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# Storage Media



**Storage Media  
is**





**Storage Media  
is  
Volatile**



## Carbon nanoballs as data storage units

September 1, 2009



Model of the metallofullerene studied consisting of 80 carbon atoms (light blue), 3 dysprosium atoms (red) and 1 nitrogen atom (dark blue).

 Enlace

Small, smaller, "nano" data storage! Interest is growing in the use of



# Carbon nanoballs as data storage units

September 1, 2009

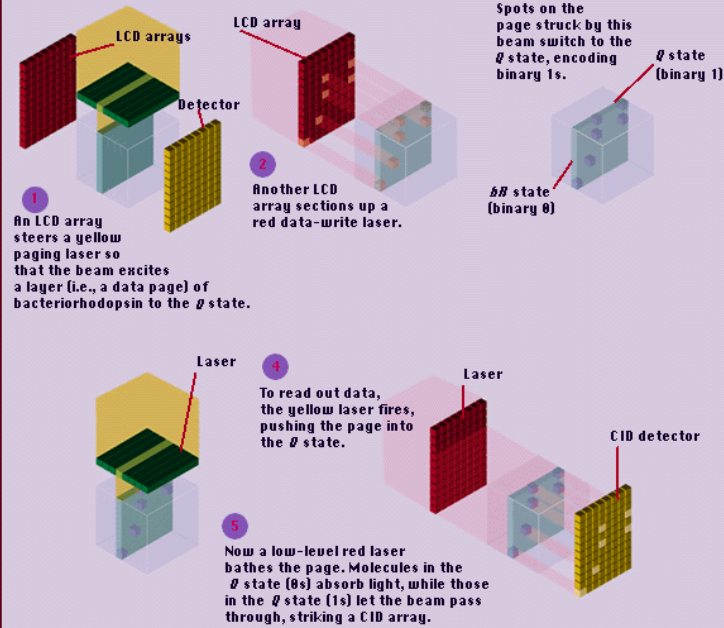


Model of the metallofullerene studied consisting of 80 carbon atoms (light blue), 3 dysprosium atoms (red) and 1 nitrogen atom (dark blue).

Enlarge

Small, smaller, "nano" data storage! Interest in

## How Molecular Memory Works



# Carbon nanoballs as data storage units

September 1, 2009

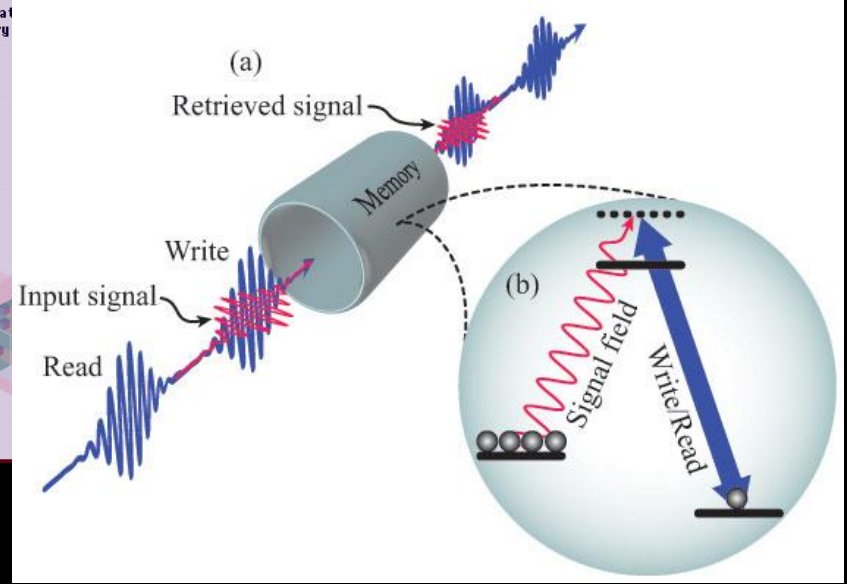
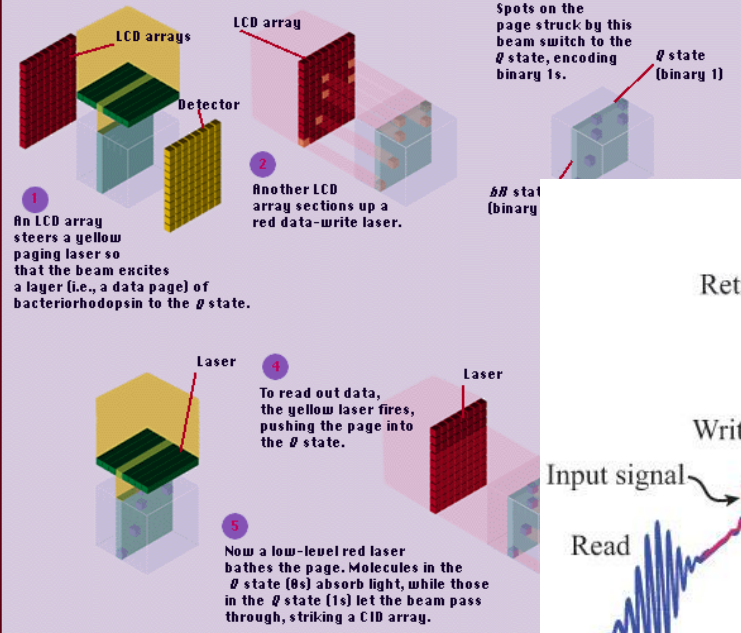


Model of the metallofullerene studied consisting of 80 carbon atoms (light blue), 3 dysprosium atoms (red) and 1 nitrogen atom (dark blue).

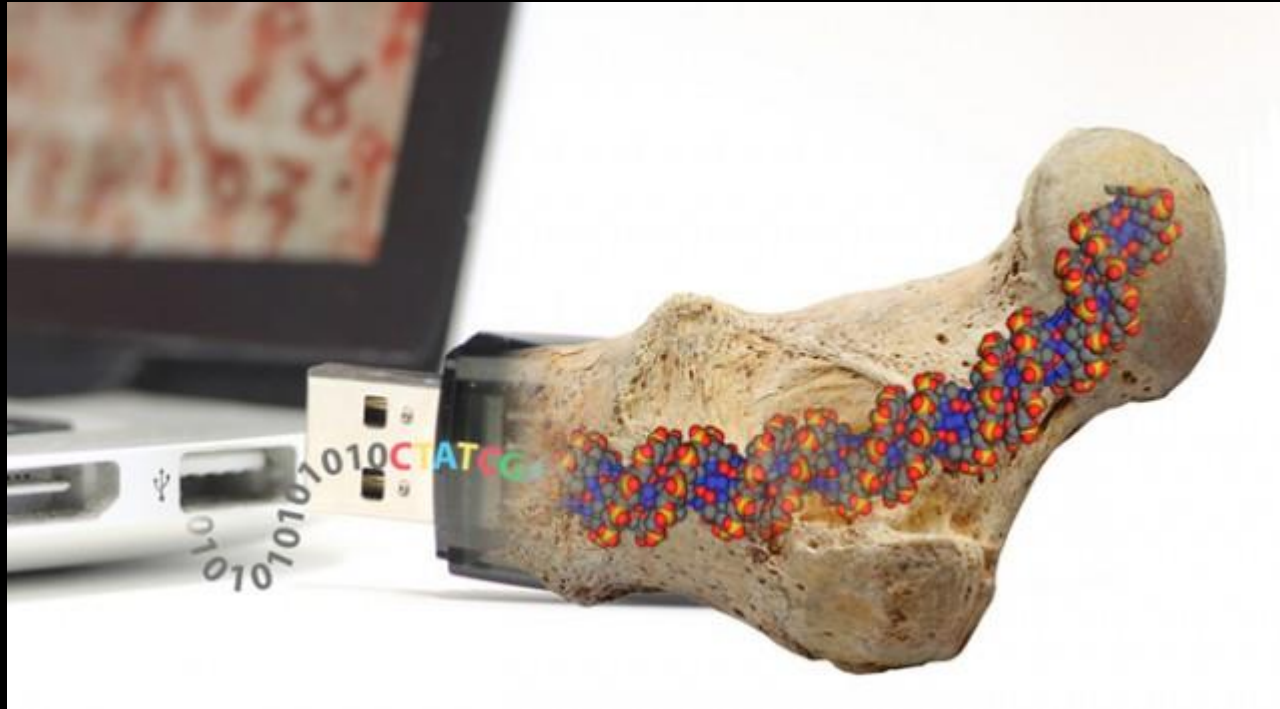
Enlace

Small, smaller, "nano" data storage! Interest in

## How Molecular Memory Works

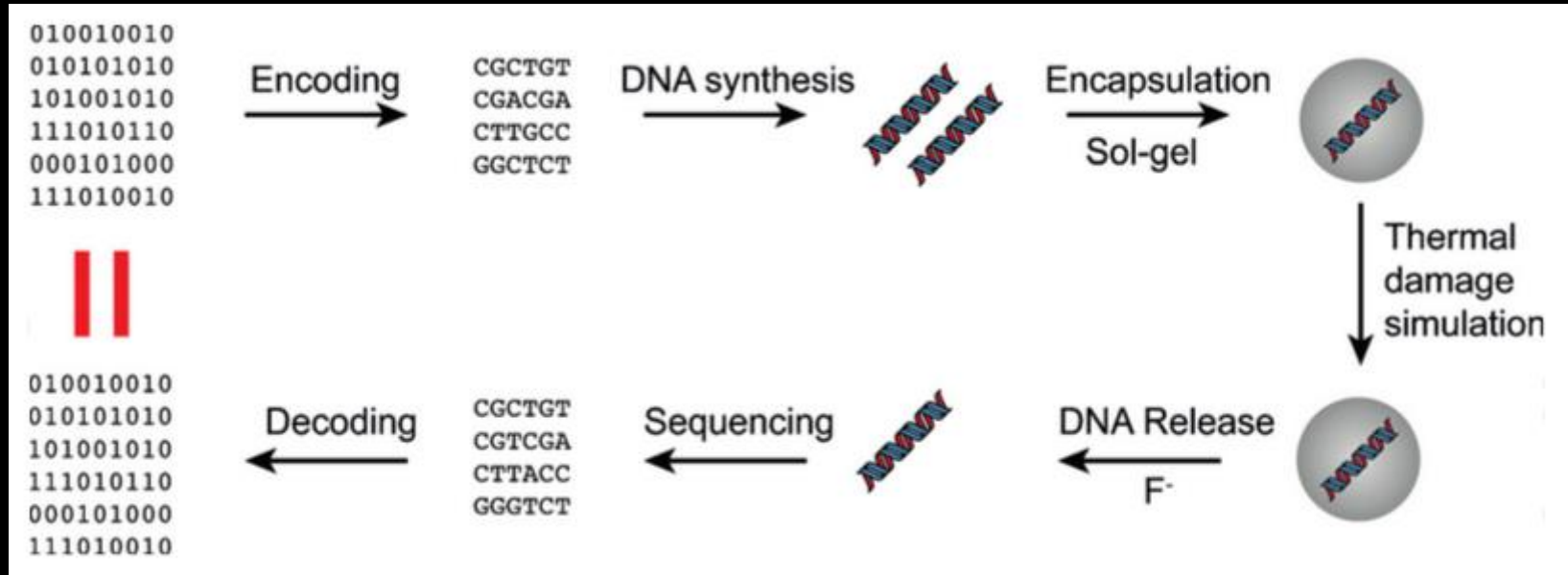


# Million-Year Data Storage via DNA



ETH Zurich, 2015

# Million-Year Data Storage via DNA













# Ravages of Time

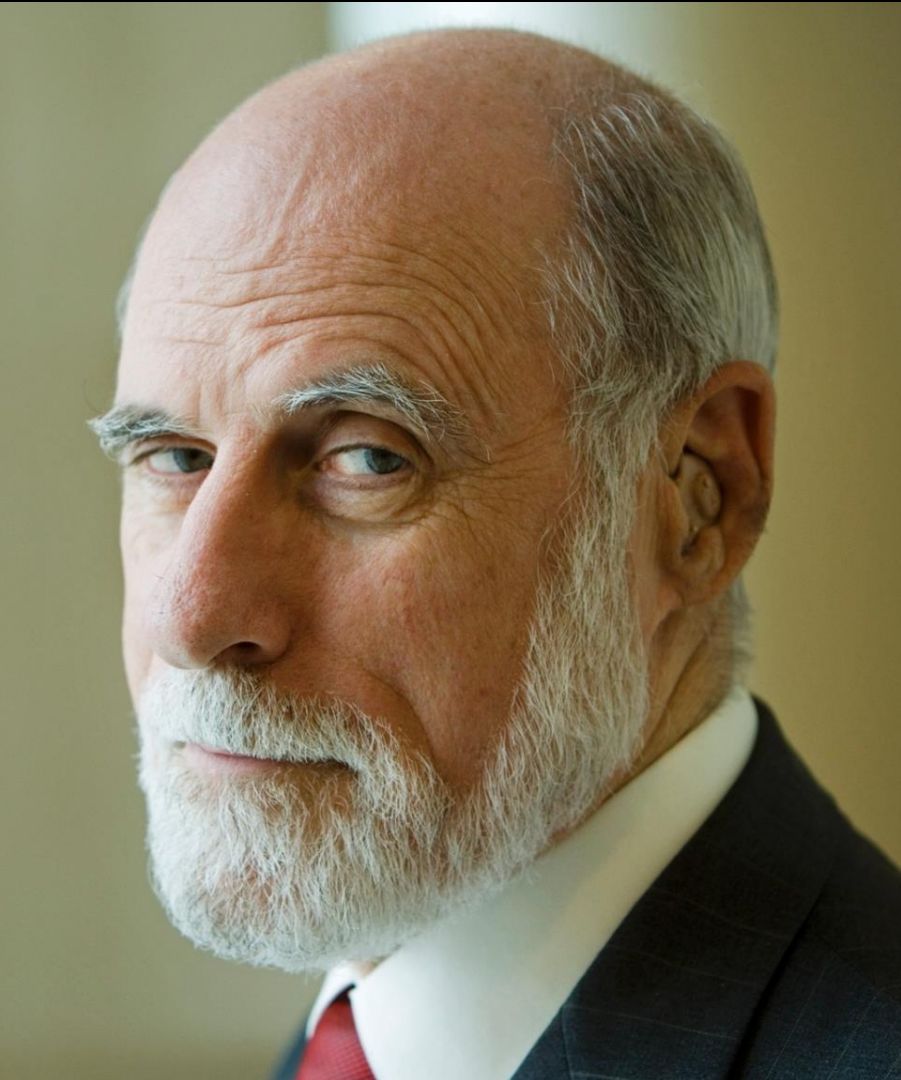
- Prepare to hold the data for 100+ years
- Be ready to migrate the data to new media
- Archive a functional app with the data



**And so...**







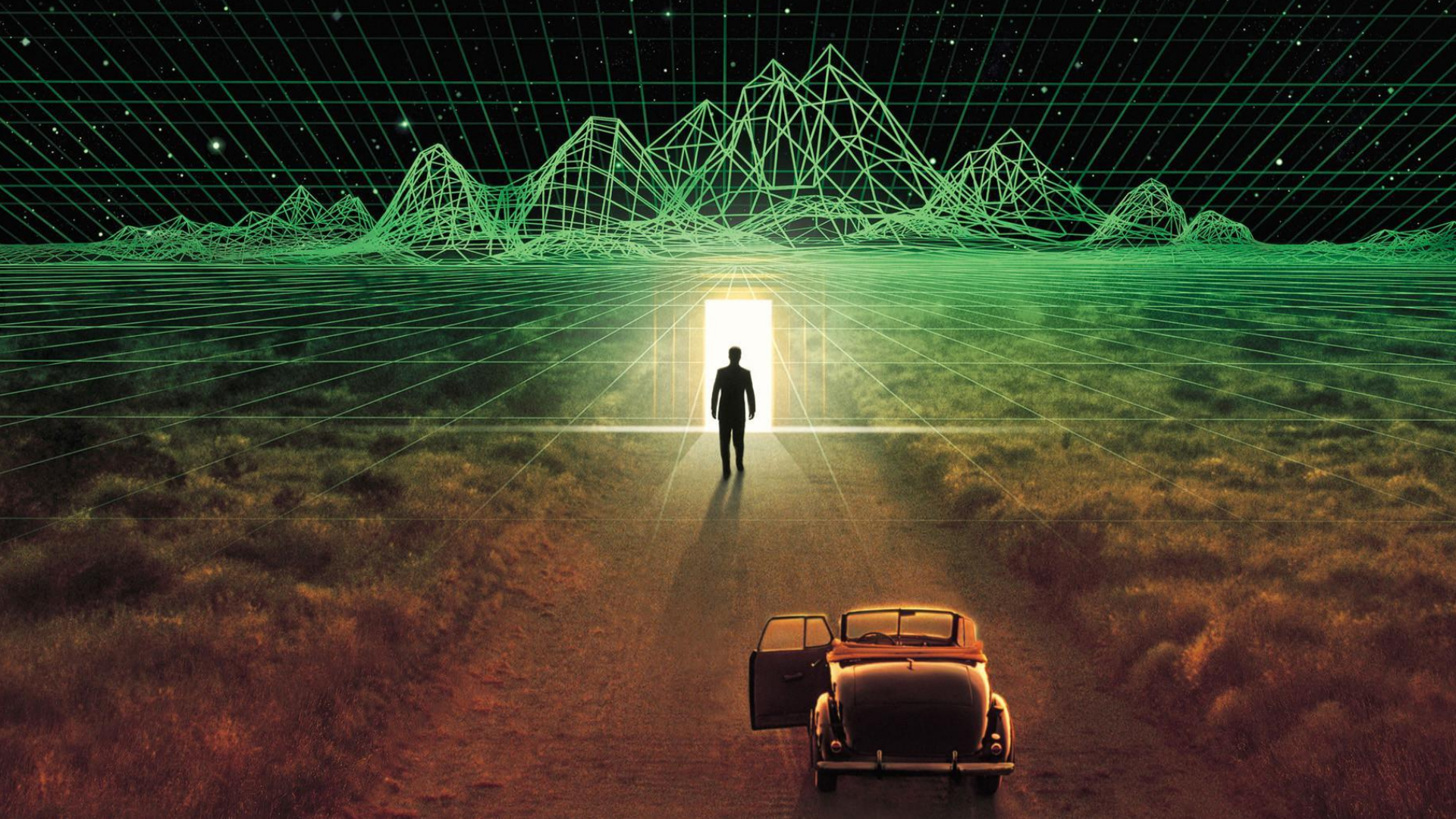
“If we don’t want our digital lives to fade away, we need to make sure that the objects we create today can still be rendered far into the future.”

**Vint Cerf, 2015**



“Those who ignore the mistakes of the future are bound to make them.”

Joseph D. Miller, 2006





412. - STRASBOURG. - Pont du Corbeau  
Raven's Bridge

# Putting Big Data in its Place

<http://g.mamund.com/2015-hhcamp>

Mike Amundsen,  
API Academy at CA  
@mamund

