

Information Service Engineering

Lecture 1: Information, Natural Language, and the Web



Leibniz Institute for Information Infrastructure

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FIZ Karlsruhe - Leibniz Institute for Information Infrastructure

AIFB - Karlsruhe Institute of Technology

Summer Semester 2021

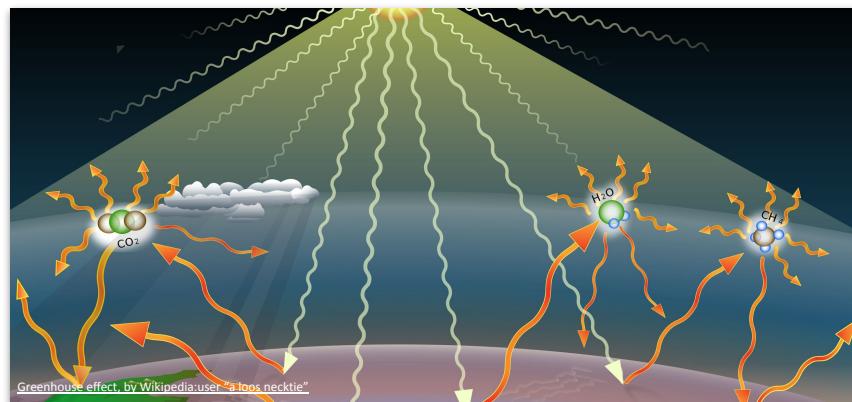
Lecture 1: Information, Natural Language, and the Web

- 1.1 How to get Information (from the Web)?
- 1.2 Communication, Language, and Understanding
- 1.3 How to measure Information?
- 1.4 The ever-growing Web of Information
- 1.5 Search Engines on the Web
- 1.6 The Meaning of Information

How to get Information (from the Web)?

Find a solution for the following question:

- **When was the Greenhouse Effect discovered?**



Ask an
Information
Service



When was the Greenhouse effect discovered?



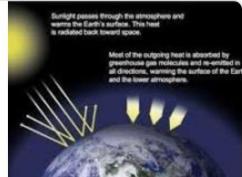
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About 14.000.000 results (0,50 seconds)

1896

The greenhouse effect was discovered more than 100 years ago

In 1896, the world renowned Swedish scientist and Nobel Prize Winner Svante Arrhenius (1859-1927), described how CO₂ influences the climate. Jun 5, 2018



phys.org › Earth › Environment

80 years since the first calculations showed that the Earth was ...

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People also ask

Who first discovered greenhouse effect?

What is greenhouse effect and global warming?

What is the cause of greenhouse effect?

Feedback

en.wikipedia.org › wiki › Greenhouse_effect

Greenhouse effect - Wikipedia

The greenhouse effect is the process by which radiation from a planet's atmosphere warms the planet's surface to a temperature above what it would be without ...

Runaway greenhouse effect · Anti-greenhouse effect · History of climate change

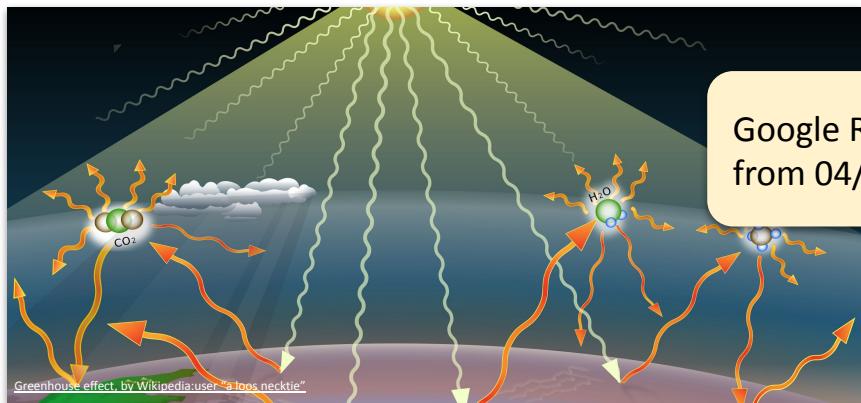
www.lenntech.com › greenhouse-effect › global-warming-history

History of the greenhouse effect and global warming - Lenntech

History of the greenhouse effect and global warming ... It was also discovered that water vapor absorbed totally different types of radiation than carbon dioxide.

Find a solution for the following question:

- When was the Greenhouse Effect discovered?



Google Result
from 04/2020

About 16.300.000 results (0,82 seconds)

1859

Irish physicist John Tyndall is commonly credited with discovering the greenhouse effect, which underpins the science of climate change. Starting in **1859**, he published a series of studies on the way greenhouse gases including carbon dioxide trapped heat in the Earth's atmosphere. 2 Sep 2016

www.climatechangenews.com › 2016/09/02 › the-woman...

Meet the woman who first identified the greenhouse effect

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People also ask

When was greenhouse effect first discovered? ▾

Who discovered green house effect? ▾

How long has the greenhouse effect been around? ▾

When did we start noticing global warming? ▾

Feedback

www.rigb.org › blog › may › who-discovered-the-gree... ▾

Who discovered the greenhouse effect? | The Royal Institution ...

17 May 2019 — Who discovered the greenhouse effect? John Tyndall set the foundation for our modern understanding of the greenhouse effect, climate change, ...

en.wikipedia.org › wiki › Greenhouse_effect ▾

Greenhouse effect - Wikipedia

The greenhouse effect is the process by which radiation from a planet's atmosphere warms the planet's surface to a temperature above what it would be without ...

[Details](#) · [Greenhouse gases](#) · [Role in climate change](#) · [Real greenhouses](#)

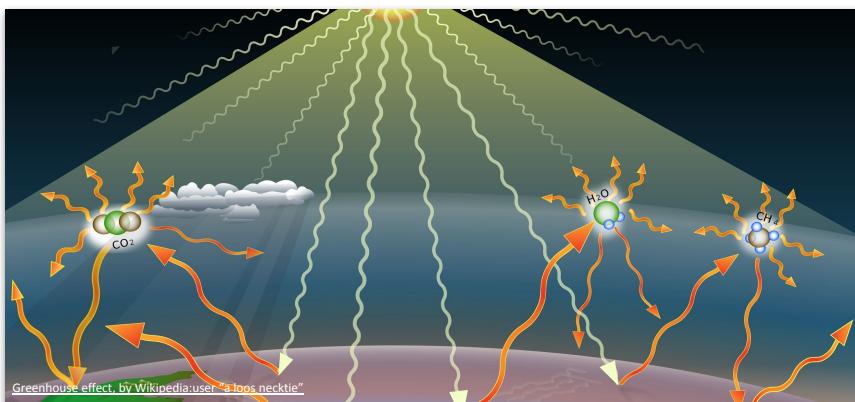
www.lenntech.com › greenhouse-effect › global-warmi... ▾

History of the greenhouse effect and global warming - Lenntech

It was also discovered that water vapor absorbed totally different types of radiation than carbon dioxide. Gilbert Plass summarized these results in 1955. He ...

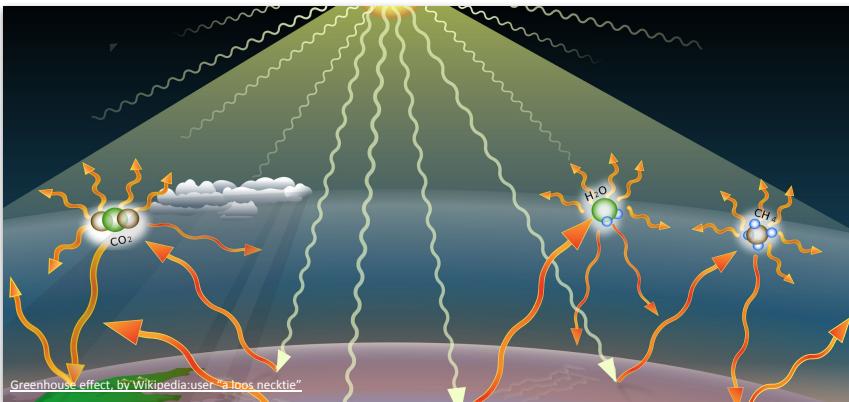
Find a solution for the following question:

- **When was the Greenhouse Effect discovered?**



Find a solution for the following question:

- When was the Greenhouse Effect discovered?



Bing Result
from 04/2020

When was the Greenhouse effect discovered?

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7,540,000 Results Any time ▾

When was the greenhouse effect discovered?

The greenhouse effect is a natural process that is millions of years old. It plays a critical role in regulating the overall temperature of the Earth. The greenhouse effect was first discovered by [Joseph Fourier](#) in 1827, experimentally verified by [John Tyndall](#) in 1861, and quantified by [Svante Arrhenius](#) in 1896.



* The greenhouse effect was discovered by Joseph Fourier in 1827, first reliably experimented on by John Tyndall in 1858, and first reported quantitatively by Svante Arrhenius in 1896.

Image: slideshare.net

[What is the greenhouse effect? | What's Your Impact](#)
whatsyourimpact.org/greenhouse-effect

Was this helpful?

PEOPLE ALSO ASK

[What are the major causes of global warming?](#) ▾

[What are facts about the greenhouse effect?](#) ▾

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[When did scientist discovered the ozone hole?](#) ▾

Feedback

History of the greenhouse effect and global warming

<https://www.lenntech.com/greenhouse-effect/global-warming-history.htm> ▾

History of the greenhouse effect and global warming Svante Arrhenius (1859-1927) was a Swedish scientist that was the first to claim in 1896 that fossil fuel combustion may eventually result in ...

Who discovered the greenhouse effect? | The Royal ...

<https://www.rigb.org/blog/2019/may/who-discovered-the-greenhouse-effect> ▾
 Who discovered the greenhouse effect? | The Royal Institution: Science Lives Here 160 years ago, on 18 May 1859, the Irish physicist John Tyndall wrote in his journal 'the subject is completely in my hands'... +

Greenhouse effect - Wikipedia

https://en.wikipedia.org/wiki/Greenhouse_effect ▾

< Overview History Description Details Greenhouse gases >

The existence of the greenhouse effect, while not named as such, was proposed by Joseph Fourier in 1824. The argument and the evidence were further strengthened by Claude Pouillet in 1827 and 1838. John Tyndall was the first to measure the infrared absorption and emission of various gases and vapours. From 1859 onwards, he showed that the effect was due to a very small proportion of the atmosphere, with the main gases having no effect, and was largely due to water vapour, though small percentages of hydrocarbons...

Wikipedia · Text under CC-BY-SA license

Discovery Of The Greenhouse Effect - Greenhouse Gases

<https://www.climate-policy-watcher.org/.../discovery-of-the-greenhouse-effect.html> 23.03.2020 · It was during the 19th century that scientists realized that gases—such as CO₂—found within the atmosphere cause a “greenhouse effect” that regulates the atmosphere’s temperature.

History of the greenhouse effect and global warming

<https://www.lenntech.com/greenhouse-effect/global> ▾
 History of the greenhouse effect and global warming. Svante Arrhenius (1859–1927) was a Swedish scientist that was the first to claim in 1896 that fossil fuel combustion may eventually result in enhanced...

History of climate change science - Wikipedia

https://en.wikipedia.org/wiki/History_of_climate_change_science ▾
 The history of the scientific discovery of climate change began in the early 19th century when ice ages and other natural changes in paleoclimate were first suspected and the natural greenhouse effect was...

How Joseph Fourier discovered the greenhouse effect

<https://www.irishtimes.com/news/science/how-joseph-fourier-discovered...> ▾
 21.03.2019 · How Joseph Fourier discovered the greenhouse effect That's Maths: French physicist's study of heat conduction led him to analyse why Earth was so warm Thu, Mar 21, 2019, 05:00

greenhouse effect | Definition, Diagram, Causes, & Facts ...

<https://www.britannica.com/science/greenhouse-effect> ▾
 French mathematician Joseph Fourier is sometimes given credit as the first person to coin the term greenhouse effect based on his conclusion in 1824 that Earth's atmosphere functioned similarly to a...

Greenhouse Effect | National Geographic Society

<https://www.nationalgeographic.org/encyclopedia/greenhouse-effect> ▾
 Since the Industrial Revolution in the late 1700s and early 1800s, people have been releasing large quantities of greenhouse gases into the atmosphere. That amount has skyrocketed in the past century...



Knowledge Graph

- **Facts
(structured data)**

Greenhouse Effect

The greenhouse effect is the process by which radiation from a planet's atmosphere warms the planet's surface to a temperature above what it would be without this atmosphere. Radiatively active gases (i.e., greenhouse gases) in a planet's atmosphere...

W Wikipedia

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Data from: Wikipedia · Apextribune

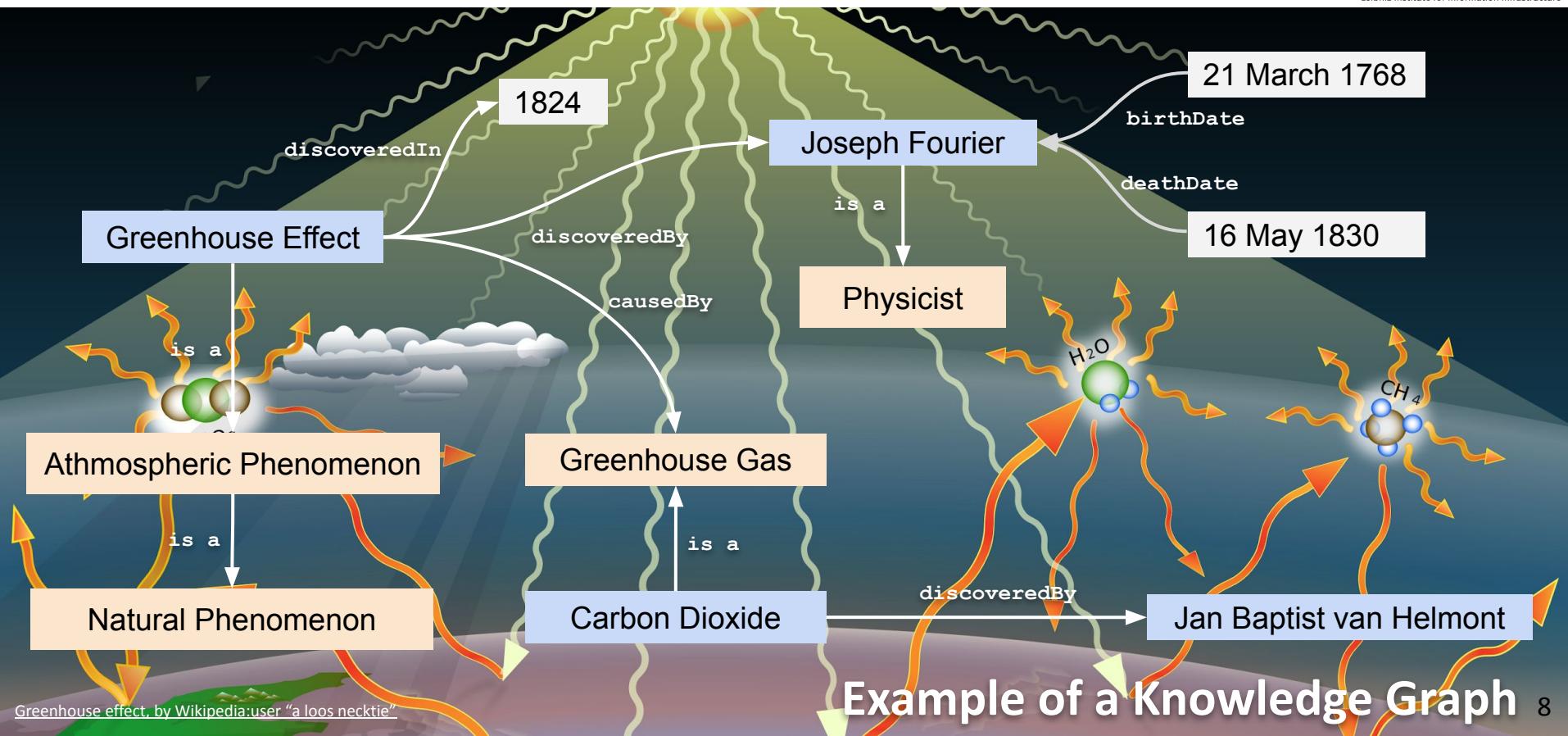
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Search Engine Indexes

- Web pages
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- Tweets
- etc.

What does it mean to know “the Greenhouse Effect”?



Lecture 1: Information, Natural Language, and the Web

1.1 How to get Information (from the Web)?

1.2 Communication, Language, and Understanding

1.3 How to measure Information?

1.4 The ever-growing Web of Information

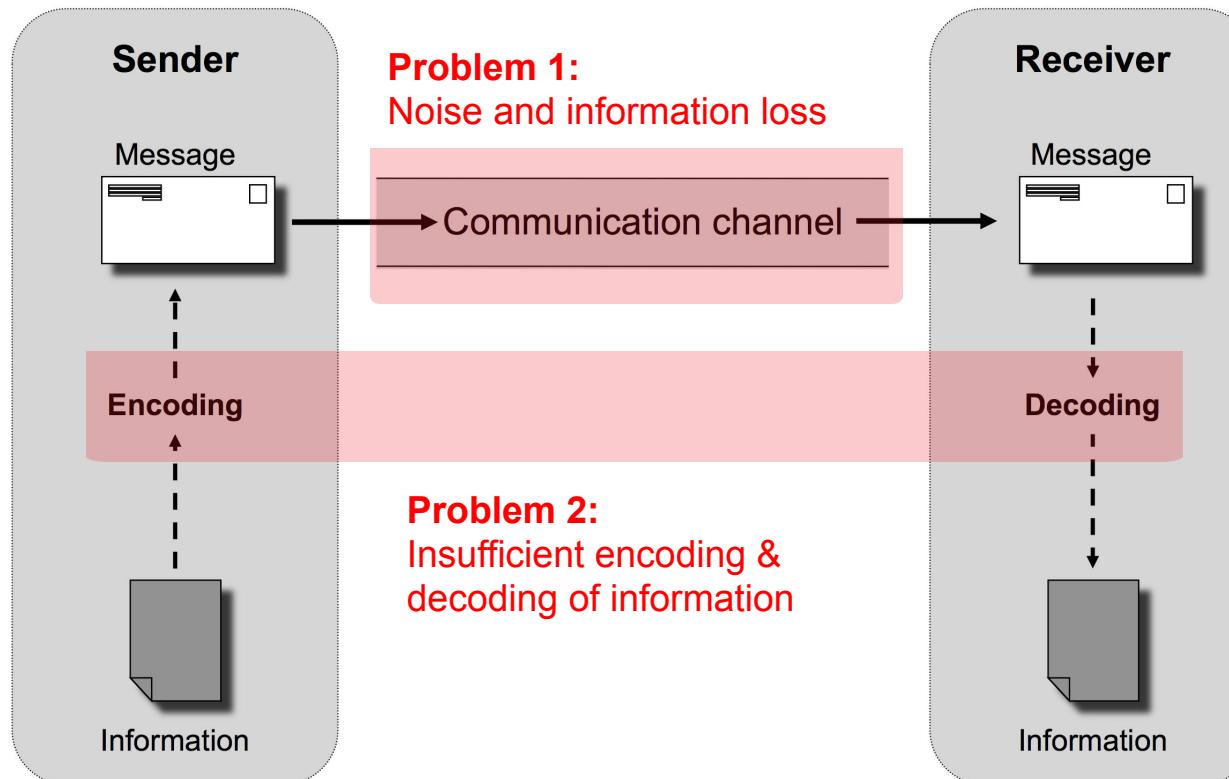
1.5 Search Engines on the Web

1.6 The Meaning of Information

What is Communication?

- **Communication** is a process by which **information** is **exchanged** between individuals through a **common system of symbols, signs, or behavior.**
[Merriam-Webster]

Communication Models - How Information is transferred



Ch. Meinel, H. Sack:
[Digital Communication - Communication Multimedia](#), Springer, 2014.

What is Language?

- **Language**, a system of conventional **spoken, manual, or written symbols** by means of which human beings, as members of a social group and participants in its culture, **express** themselves.
- The functions of language include **communication**, the expression of identity, play, imaginative expression, and emotional release.

[Encyclopaedia Britannica]



Natural Language

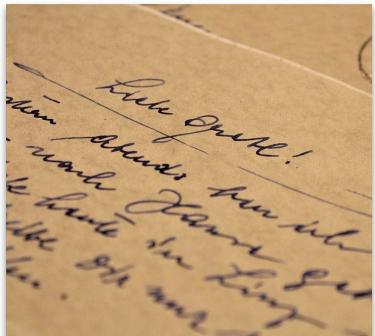
- Natural language is a discrete categorical system of symbols that combine to **convey meaning**.
- It has **evolved naturally and historically in humans** through use and repetition **without planning**.
- A natural language is **different from a constructed or formal language (artificial language)**, such as an auxiliary language (Esperanto), a programming language (C, Python, Java, etc.), arithmetic language, or a language used to study logic.

How do we communicate Natural Language?



Speech

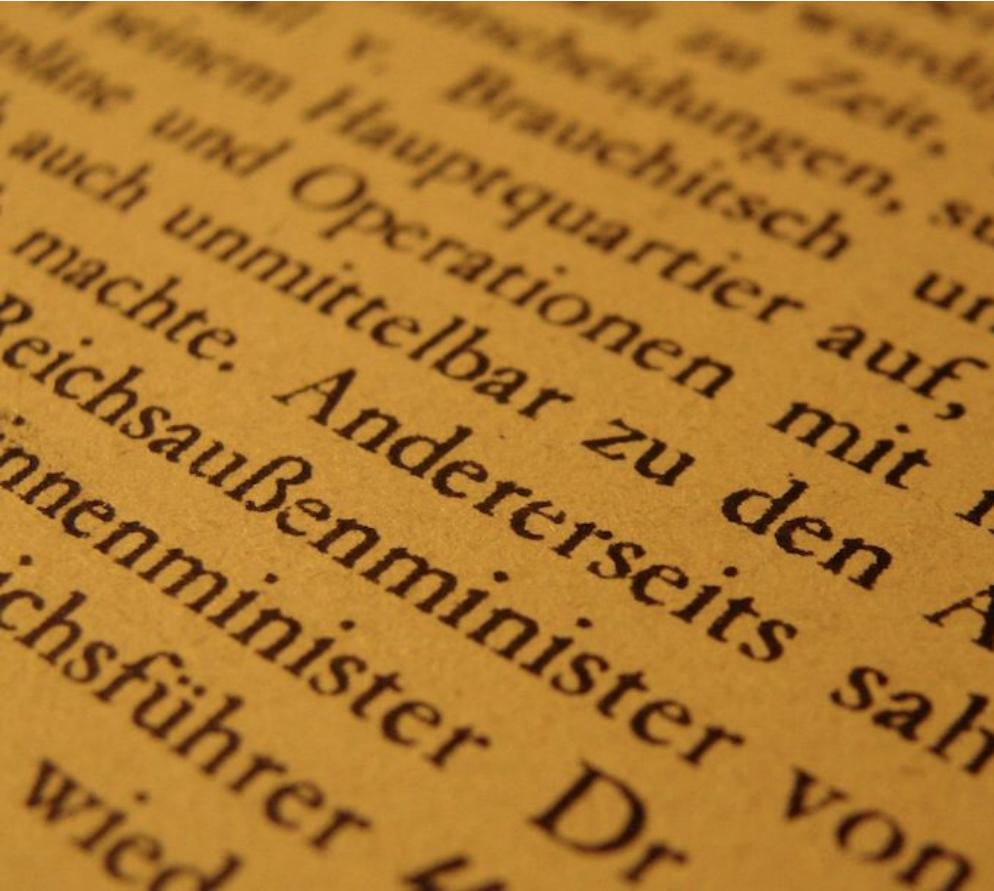
- Listening
- Speaking



Text

- Reading
- Writing

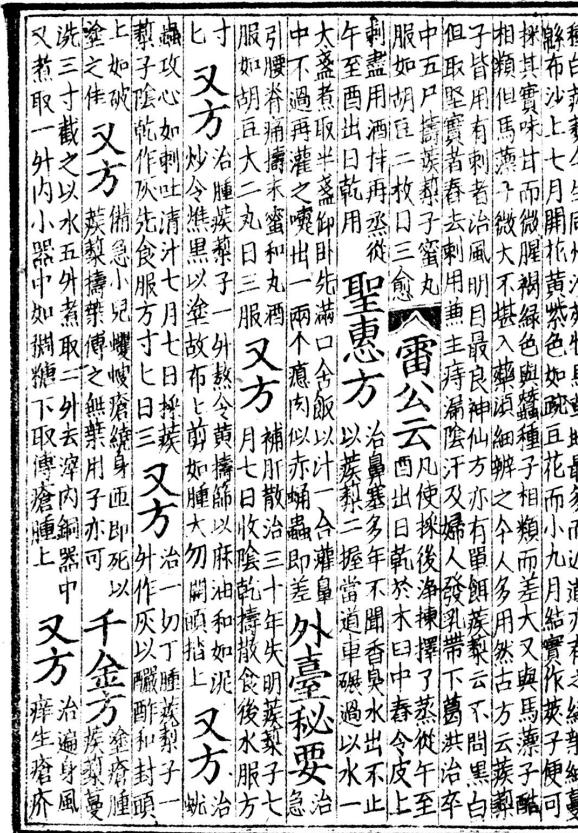
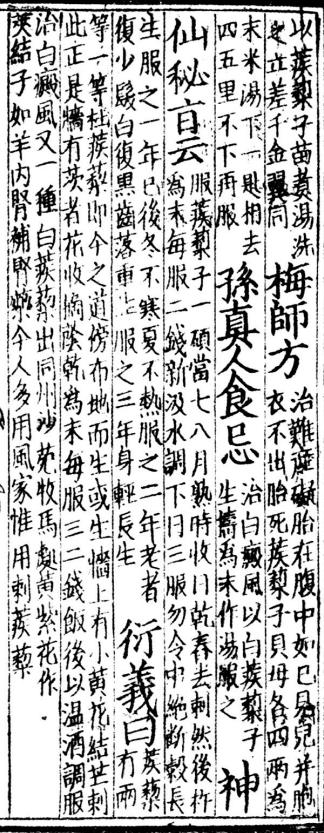
How do we encode Textual Information?



Alphabetic Writing System

- A single character refers to a single sound (*phonemic alphabet*).
- In **consonant alphabets (abjads)**, vowels can be deduced from context.

How do we encode Textual Information?



Syllabic and Logographic Writing System

- **Syllabic systems** also involve a mapping between characters and sound, (*but refer on larger units*).
- A **logograph** is a symbol that represents a unit of meaning.

Artificial Language

```

public static void main(String[] args) throws FileNotFoundException {

    String filePath = "/Users/hsa/Documents/Workspace/Scientometrics2016/testdata_input";
    File fout = new File("/Users/hsa/Documents/Workspace/Scientometrics2016/SemanticSim_testdata_10000");
    FileOutputStream fos = new FileOutputStream(fout);

    try {
        BufferedReader lineReader = new BufferedReader(new FileReader(filePath));
        BufferedWriter bw = new BufferedWriter(new OutputStreamWriter(fos));
        String lineText = null;
        int nr=0;

        while ((lineText = lineReader.readLine()) != null) {

            String[] splitStr = lineText.split("\\s+");
            nr++;

            // DBpedia settings - without giving prefix list, using property patterns instead
            // it will filter properties which start with "http://dbpedia.org/ontology"
            ResourceSimilarityMeasure rsmForDBpedia = new ResourceSimilarityMeasure(
                PropertyRestriction.SamePropertyPath,
                "http://dbpedia.org/sparql",
                null,
                "http://dbpedia.org/ontology/",
                null, null, null, null);
            System.out.println(
                rsmForDBpedia.getSimilarity("<http://dbpedia.org/resource/Albert_Einstein>", "<http://dbpedia.org/re
  
```

1. Information, Natural Language and the Web

1.2 Communication, Language, and Understanding?

What does it mean to understand?

- **Understanding** is the ability to grasp the meaning of information.
- **Information** is conveyed in a **message** using a specific **language**.
- **Information is understood** by the receiver of a message,
if the receiver **interprets** the information **correctly**.

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1. Information, Natural Language and the Web

1.3 How to measure Information?

What is information?

- **Information** is that which informs.
- **Information** is conveyed as the **content of a message**.
- **Information** can be **encoded** into various forms for **transmission** and **interpretation**.
- **Information** is any **propagation of cause and effect** within a system.
- **Information's existence** is not necessarily coupled to an **observer**.
- **Information reduces uncertainty (Information Theory)**.

Information according to Information Theory

- **Information reduces uncertainty.**
- **Uncertainty of an event** is measured by its **probability of occurrence** and is **inversely proportional** to that.
- The **more uncertain** an event, the **more information** is required to resolve uncertainty of that event.

Information Content

Discrete Random Variable

- A **random variable** x takes a value x from the alphabet \mathbf{X} with probability $p_x(x)$.
- The **vector of probabilities** is $\vec{p}(x)$ (**probability mass function**).

Information Content

Discrete Random Variable

- Examples:

- Coin Tossing:

- $\mathbf{X} = [\text{head}; \text{tail}] ; \vec{p}(x) = [\frac{1}{2}; \frac{1}{2}]$

- Dice Tossing:

- $\mathbf{X} = [1; 2; 3; 4; 5; 6] ; \vec{p}(x) = [\frac{1}{6}; \frac{1}{6}; \frac{1}{6}; \frac{1}{6}; \frac{1}{6}; \frac{1}{6}]$

- German language:

- $\mathbf{X} = [\text{a}; \text{b}; \text{c}; \text{d}; \dots; \text{z}] ; \vec{p}(x) = [0.0651; 0.0189; 0.0306; 0.0508; \dots; 0.0103]$

Shannon Information Content

- The **Shannon Information Content** of an outcome with probability p is:

$$SIC = -\log_2 p$$

- The unit to measure information is **bit**.
(*binary digit, basic indissoluble information unit*)



[Claude E. Shannon](#)
(1916-2001)

Shannon Information Content

- **Examples:**

- Coin Tossing:

- $\mathbf{X} = [\text{head; tail}] ; \vec{p}(x) = [\frac{1}{2}; \frac{1}{2}] ; \mathbf{SIC} = [1; 1] \text{ bit}$

- My birthday:

- $\mathbf{X} = [\text{birthday; no birthday}] ; \vec{p}(x) = [\frac{1}{365}; \frac{364}{365}] ; \mathbf{SIC} = [8.512; 0.004] \text{ bit}$

Entropy

- The **Information Content (Entropy) H** of a message M is based on the information content of each symbol $s \in M$ and its relative frequency of occurrence (probability):

$$H(\vec{p}_x) = |M| \cdot \sum_{i=1}^n p_i \cdot (-\log_2 p_i))$$

Entropy Example

$$H(\vec{p}_x) = |M| \cdot \sum_{i=1}^n p_i \cdot (-\log_2 p_i))$$



$$= 31 \times 3.48375 = \mathbf{107.99625}$$

Shannon entropy calculator

Real example how to calculate and interpret information entropy

Your string is: **information service engineering**

Alphabet of symbols in the string: **a c e f g i m n o r s t v**

Frequencies of alphabet symbols:

- 0.065 -> e
- 0.032 -> a
- 0.032 -> c
- 0.161 -> f
- 0.032 -> g
- 0.065 -> i
- 0.161 -> m
- 0.032 -> n
- 0.065 -> o
- 0.097 -> r
- 0.032 -> s
- 0.032 -> t
- 0.032 -> v

Shannon entropy can be calculated as follow:

$$\begin{aligned} H(X) &= -[(0.065 \log_2 0.065) + (0.032 \log_2 0.032) + (0.032 \log_2 0.032) + (0.161 \log_2 0.161) + \\ &(0.032 \log_2 0.032) + (0.065 \log_2 0.065) + (0.161 \log_2 0.161) + (0.032 \log_2 0.032) + (0.161 \log_2 0.161) + \\ &(0.065 \log_2 0.065) + (0.097 \log_2 0.097) + (0.032 \log_2 0.032) + (0.032 \log_2 0.032) + (0.032 \log_2 0.032)] \end{aligned}$$

$$\begin{aligned} H(X) &= -[(-0.255) + (-0.16) + (-0.16) + (-0.425) + (-0.16) + (-0.255) + (-0.425) + (-0.16) + (-0.425) + \\ &(-0.255) + (-0.326) + (-0.16) + (-0.16) + (-0.16)] \end{aligned}$$

$$H(X) = -[-3.48375]$$

$$H(X) = 3.48375$$

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There seem to be no Limits of Growth



[Cisco Annual Internet Report \(2018 - 2023\)](#)

“The Web is big.

Really big.

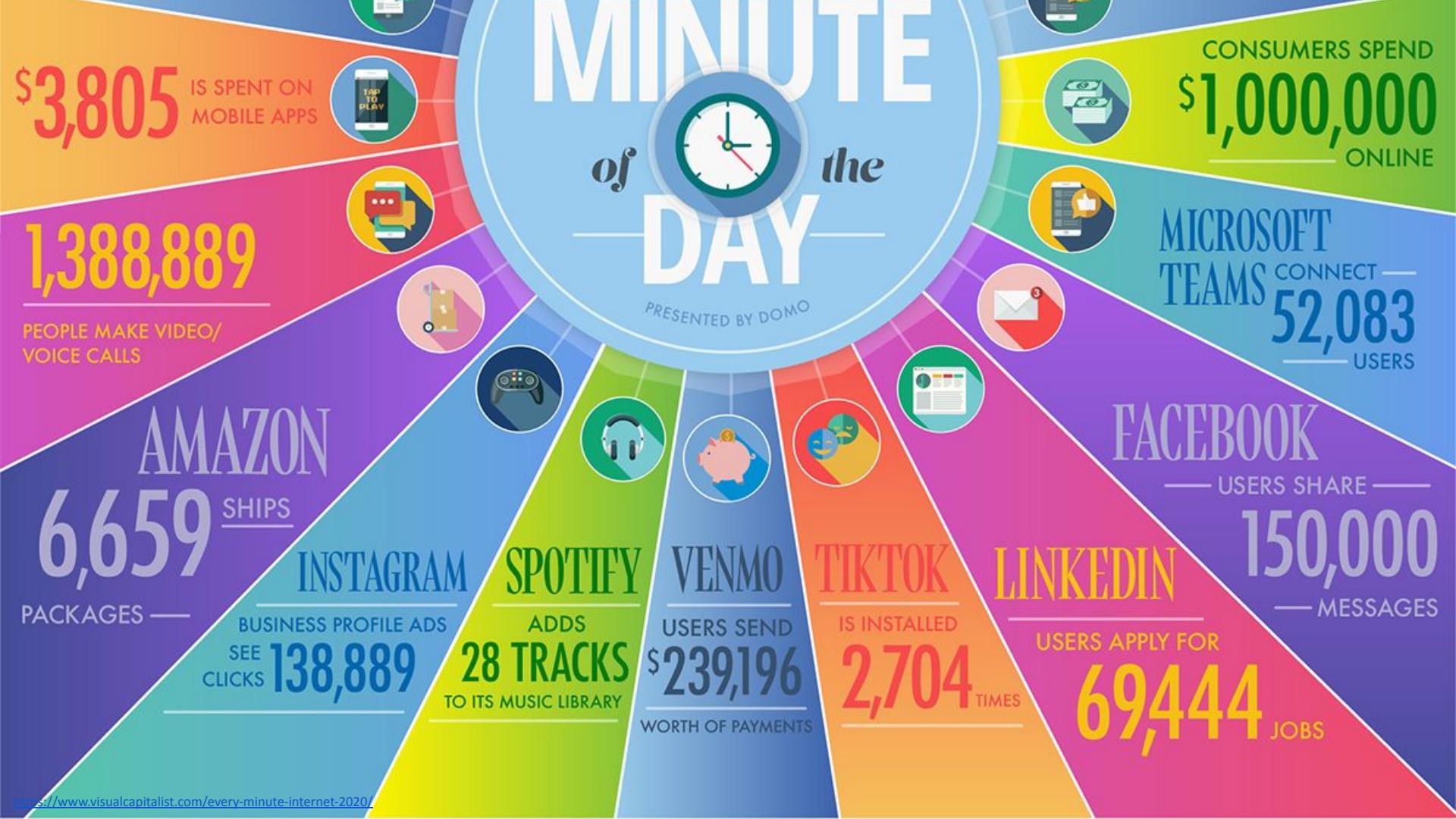
You just won't believe how vastly, hugely,
mind-bogglingly big it is.”

(...according to Douglas Adams)

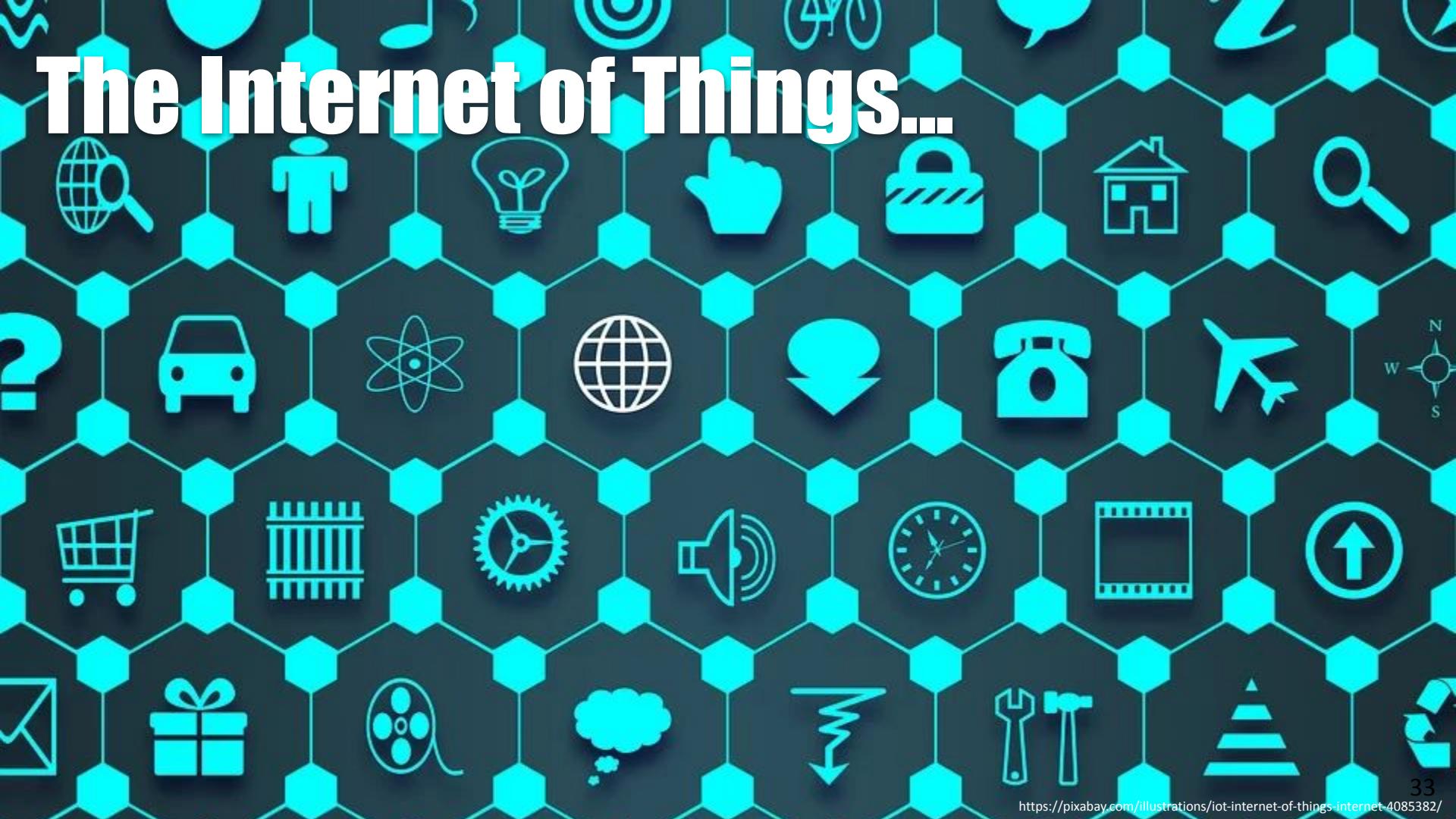


MINUTE of the DAY

PRESNTED BY DOMO



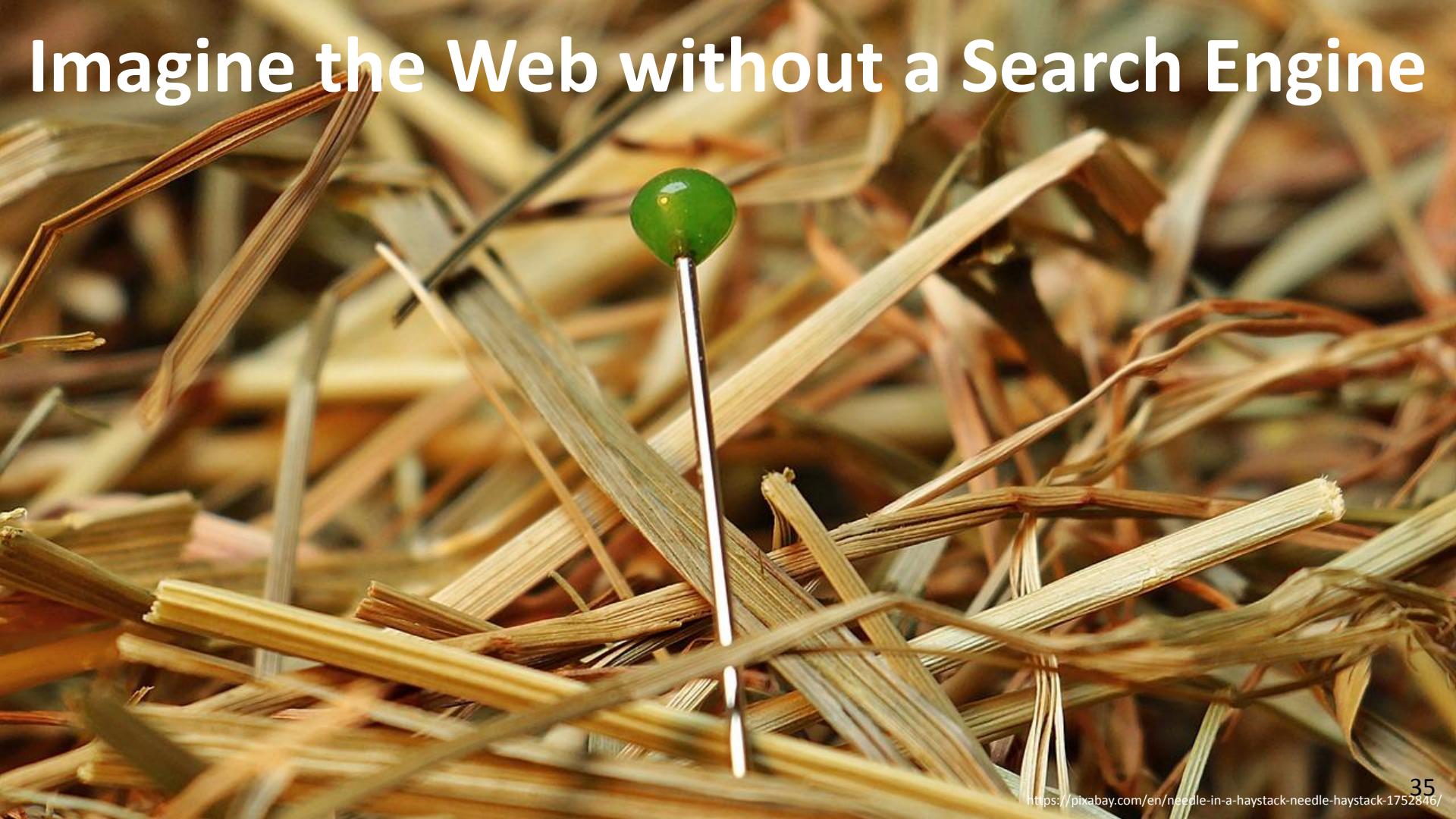
The Internet of Things...



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Imagine the Web without a Search Engine



climate chang|



climate change

climate change definition

climate change hoax

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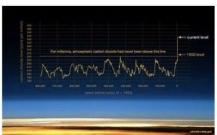
NASA: Climate Change and Global Warming

<https://climate.nasa.gov> ▾

Mar 16, 2020 · NASA's Climate Kids website brings the exciting science of climate change and sustainability to life, providing clear explanations for the big questions in climate science. Targeting upper-elementary-aged children, the site includes interactive games, hands-on activities, and engaging articles that make climate science accessible and fun.



Arctic Ice Melt Is Changing
Ocean Currents – Climate
Change: Vital Signs of the ...



Graphic: The relentless rise of
carbon dioxide – Climate
Change: Vital Signs of the ...



Study Confirms Climate
Models are Getting Future
Warming Projections ...

climate change | Causes, Effects, & Facts | Britannica

<https://www.britannica.com/science/climate-change> ▾

Climate change, the periodic modification of Earth's climate caused by changes in the atmosphere and interactions between the atmosphere and various other geologic, chemical, biological, and geographic factors. Learn how climate has changed since the last ice ...

[Evidence for Climate Change](#) · [Climate Change Within a Human Life Span](#) · [Greenhouse Gases](#)

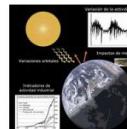
What Is Climate Change? | NASA

<https://www.nasa.gov/audience/forstudents/k-4/> ... ▾

To learn about climate change, you first must know what climate is.

Remove

Climate Change



Climate change occurs when changes in Earth's climate system result in new weather patterns that remain in place for an extended period of time. This length of time can be as short as a few decades to as long as millions of years. Scientists have identified many episodes of climate change during Earth's geological history; more recently since the industrial revolution the climate has increasingly been affected by human activities driving global warming, and the terms are commonly used interchangeably in that context.

W Wikipedia

People also search for



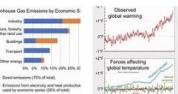
Global
Warming



Greenhouse
Effect



Deforestati...



Climate
Change and
Agriculture

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See results for

Global Warming

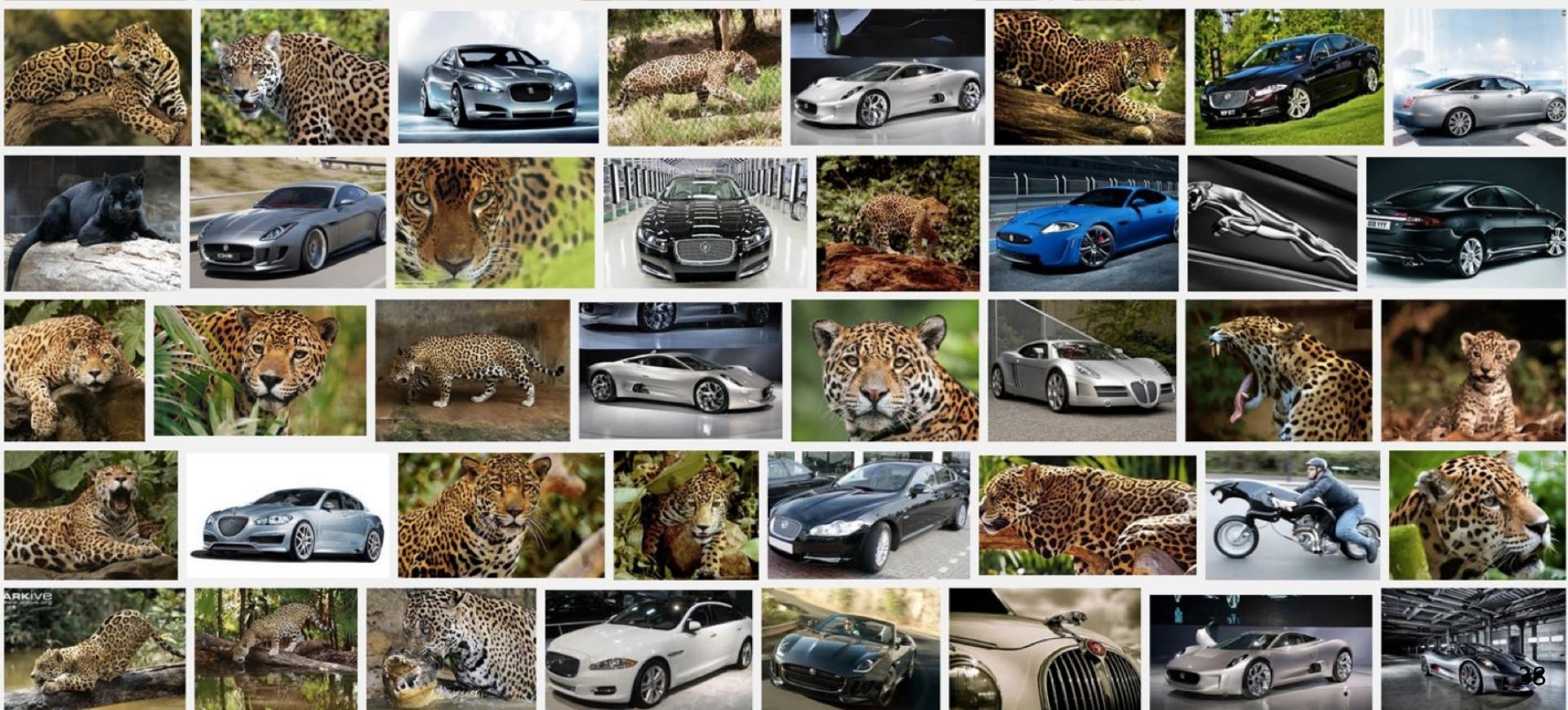
Global warming is the long-term rise in the average



Search Engines and the Web

- The World Wide Web is a **distributed hypermedia system** with
 - multimedia documents and
 - linked via hyperlinks

Do you always find what you are looking for?





視聴方法

番組表

カスタマーサービス



ニュース・報道 ドrama 映画 ドキュメンタリー パラエティ 音楽 生活情報 趣味・教養 スポーツ アニメ キッズ テレビジャパンCLUB

おすすめ番組

映画

- ▶ テレビジャパン・シネマシアター「火垂るの墓」<英語字幕付き>
- ▶ テレビジャパン・シネマシアター「ルパン三世」
- ▶ テレビジャパン・シネマシアター「謝罪の王様<英語字幕付き>」

ドラマ

- ▶ ドラマ10「美女と男子」
- ▶ ドラマ「刑事7人」
- ▶ 戦後70年「一番電車が走った」
- ▶ 木曜時代劇「まんまと～麻之助裁定帳～」
- ▶ ドラマ「レボリューション」

ドキュメンタリー

- ▶ NHKスペシャル
- ▶ ザ・プレミアム 鈴木亮平 “絶景！ミステリー遺産”に挑む！アドリア海縦断・7日間の大冒険
- ▶ ザ・プレミアム 風雲！大歴史実験
- ▶ NHKスペシャル
- ▶ BS1スペシャル「戦火のマエストロ・近衛秀磨～ユダヤ人の命を救った音楽家～」
- ▶ 世界ふれあい街歩き
- ▶ 奇跡のレッスン～世界の最強コーチと子どもたち～



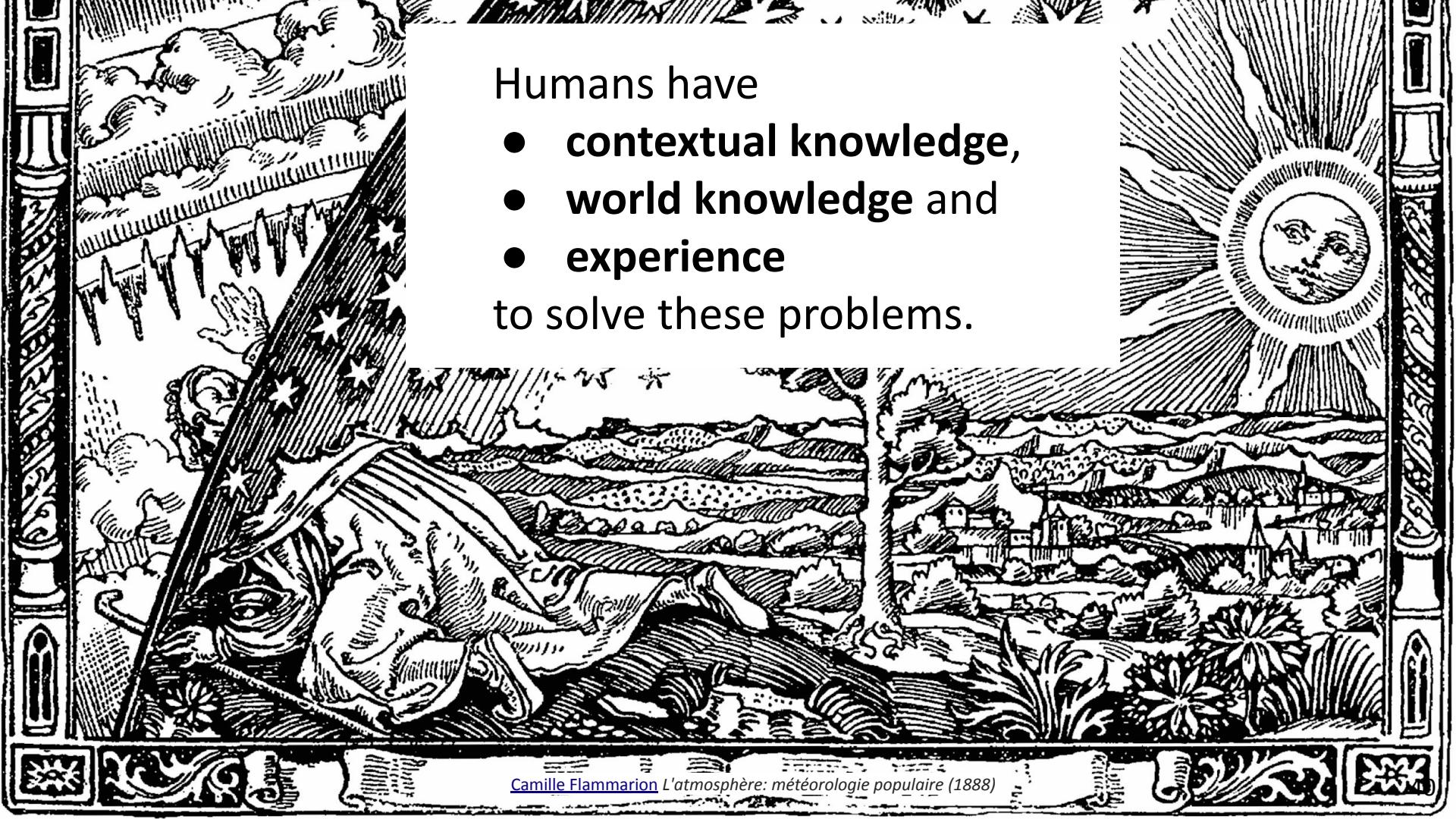
- Which information is important and how do you know?
- Which information can be trusted?
- Which information is related by content?
- What does the information mean?

- ▶ よみがえりマイスター
- ▶ 夏のうまい旅祭り 妄想ニホン キッチンが走る！
- ▶ 新 クイズ面白ゼミナール
- ▶ 『生まれに日本ノ糸～』

▶ NHKスペシャル

音楽

▶ SONGS



Humans have

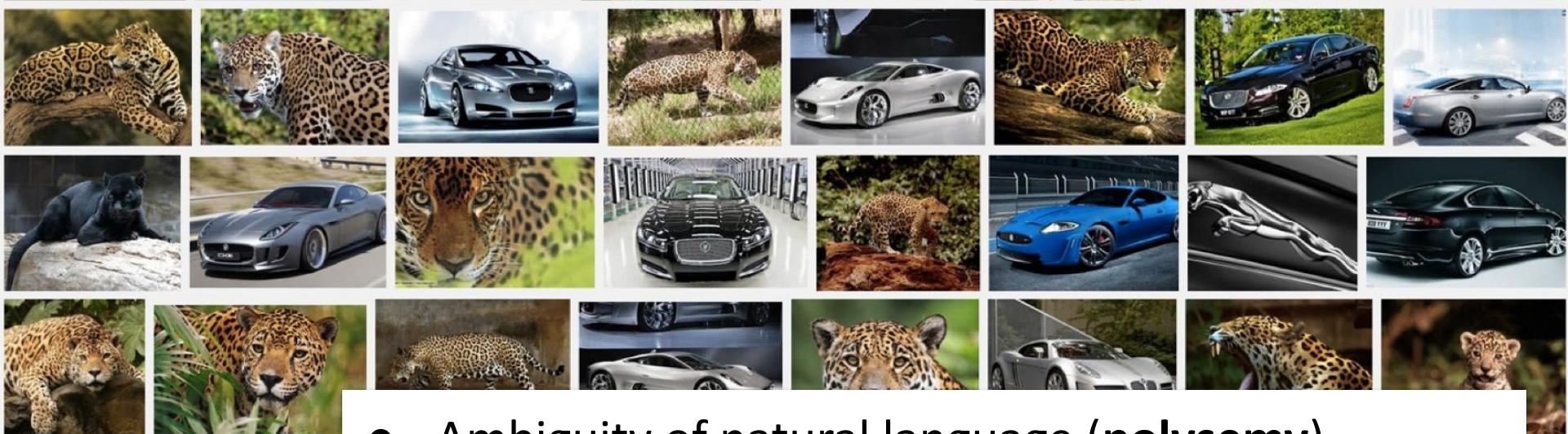
- **contextual knowledge,**
- **world knowledge** and
- **experience**

to solve these problems.

The (Document) Web is for Humans

- The Web is based on the **markup language HTML**
- HTML describes
 - how information is **presented**
 - how information is linked
 - **but not, what the information means**

The Information Retrieval Dilemma



- Ambiguity of natural language (**polysemy**)
- Different words/expressions for the same concept (**synonyms, metaphors, paraphrases**)

Lecture 1: Information, Natural Language, and the Web

1.1 How to get Information (from the Web)?

1.2 Communication, Language, and Understanding

1.3 How to measure Information?

1.4 The ever-growing Web of Information

1.5 Search Engines on the Web

1.6 The Meaning of Information

What is Meaning?

- (*In the philosophy of language, metaphysics, and metasemantics,*)
- **Meaning** is a relationship between two sorts of things:
 - **Signs** and
 - the kinds of things they **intend, express, or signify.**
- **Words** (and nonverbal symbols) are **necessarily meaningful**

What does it mean “to understand”?

- **Understanding** (in general) is the ability to grasp the meaning of information.
- **Information** is conveyed in a **message** using a specific **language** from a sender to a receiver.
- **Information is understood** by the receiver of a message, if the receiver **interprets** the information **correctly**.

Meaning and Comprehension

- **Correct Interpretation (Understanding)** depends on
 - Syntax,
 - Semantics,
 - Context,
 - Pragmatics, and
 - Experience.

Syntax

- = [greek] *Arrangement, Ordering*
- In **grammatics**, syntax denotes the study of the **principles** and processes **by which sentences are constructed** in particular languages.
- In **formal languages**, syntax is just a set of rules, by which **well formed expressions** can be created from a fundamental set of symbols (alphabet).

Semantics

- = [greek] *pertains to the character, the study of meaning*
- Semantics is part of the linguistics focussed on **Sense and Meaning** of language or symbols of language.
- Semantics is the **study of interpretation of signs or symbols** as used by agents or communities within particular circumstances and **contexts**.
- Semantics asks, **how sense and meaning of complex concepts can be derived from simple concepts** based on the **rules of syntax**.
- The semantics of a message depends on **context** and **pragmatics**.

Context

- [lat.] *contextus* = *interweaved*
- Context denotes the **surrounding of a symbol** (concept) in an expression resp. its **relationship with surrounding expressions** (concepts) and further related elements (**verbal context**).
- Contexts denotes **all elements of any sort of communication that define the interpretation of the communicated content**, as e.g.
 - social context
 - temporal context
 - cultural context

Pragmatics

- = [greek] *action*
- Pragmatics reflects the **intention by which the language is used** to communicate a message.
- In linguistics pragmatics denotes the **study of applying language in different situations**.
- It also **denotes the intended purpose** of the speaker.
- Pragmatics studies **the ways in which context contributes to meaning**.

Semantics vs. Pragmatics

- The boundary between semantics and pragmatics is open for debate.
- In this lecture, we say that **semantics looks at the literal meaning of a sentence**, while **pragmatics investigates the meaning of an utterance**, that is, the use of the sentence.

Example sentences

1. Stand up, Bob! (*imperative; command*)
2. Could you please stand up, Bob? (*interrogative; question*)
3. Bob stands up. (*assertive; statement*)

Do all speech acts (1, 2 and 3) have the same meaning?

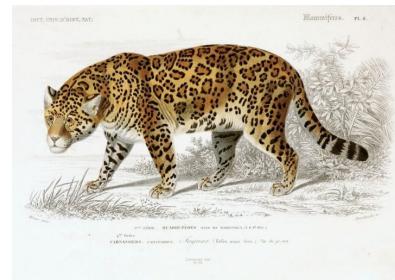
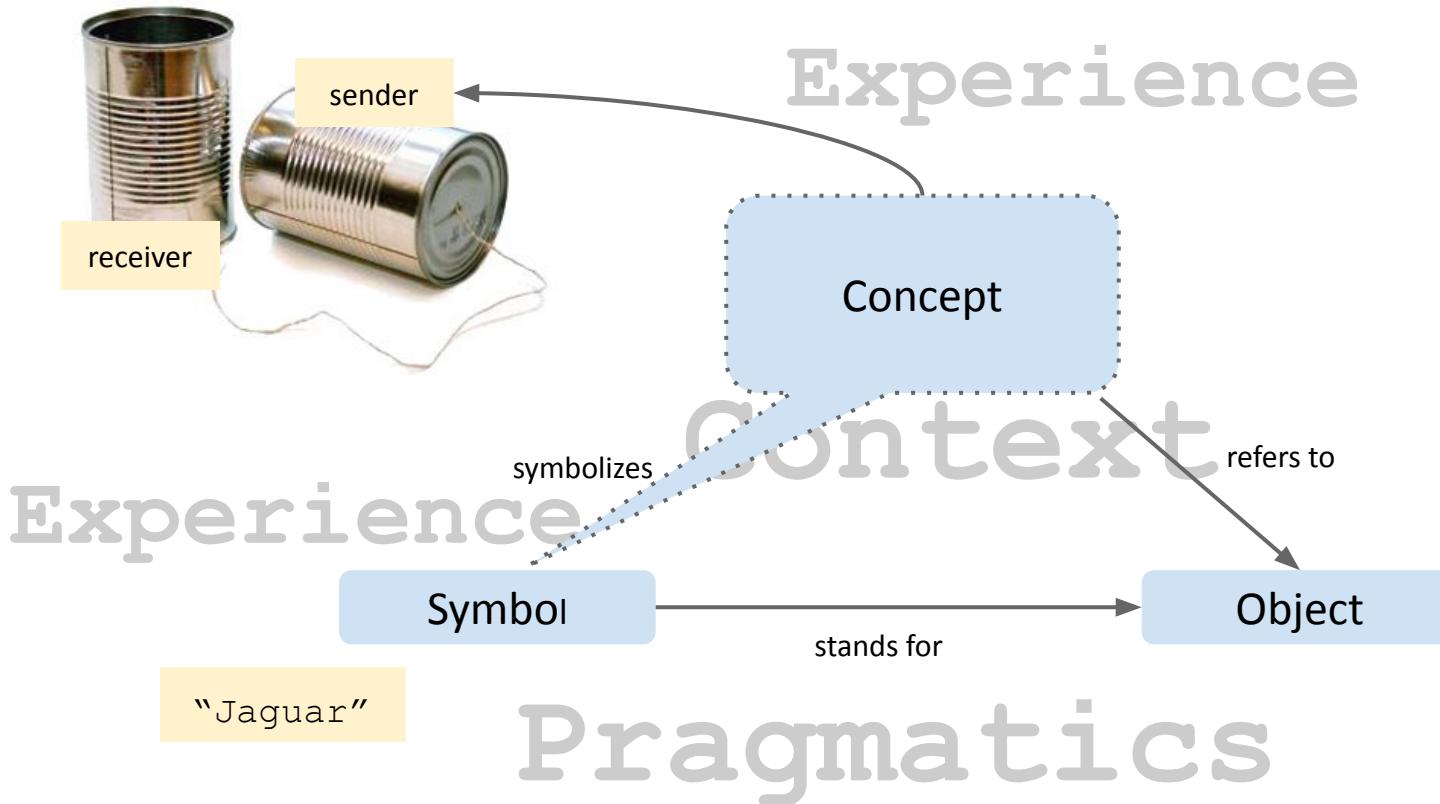
Experience

- **Experience** considers all information that you have learned and put in context with the world you are living in.
- Experience in this sense is often referred to as **common sense knowledge** or **world knowledge**.

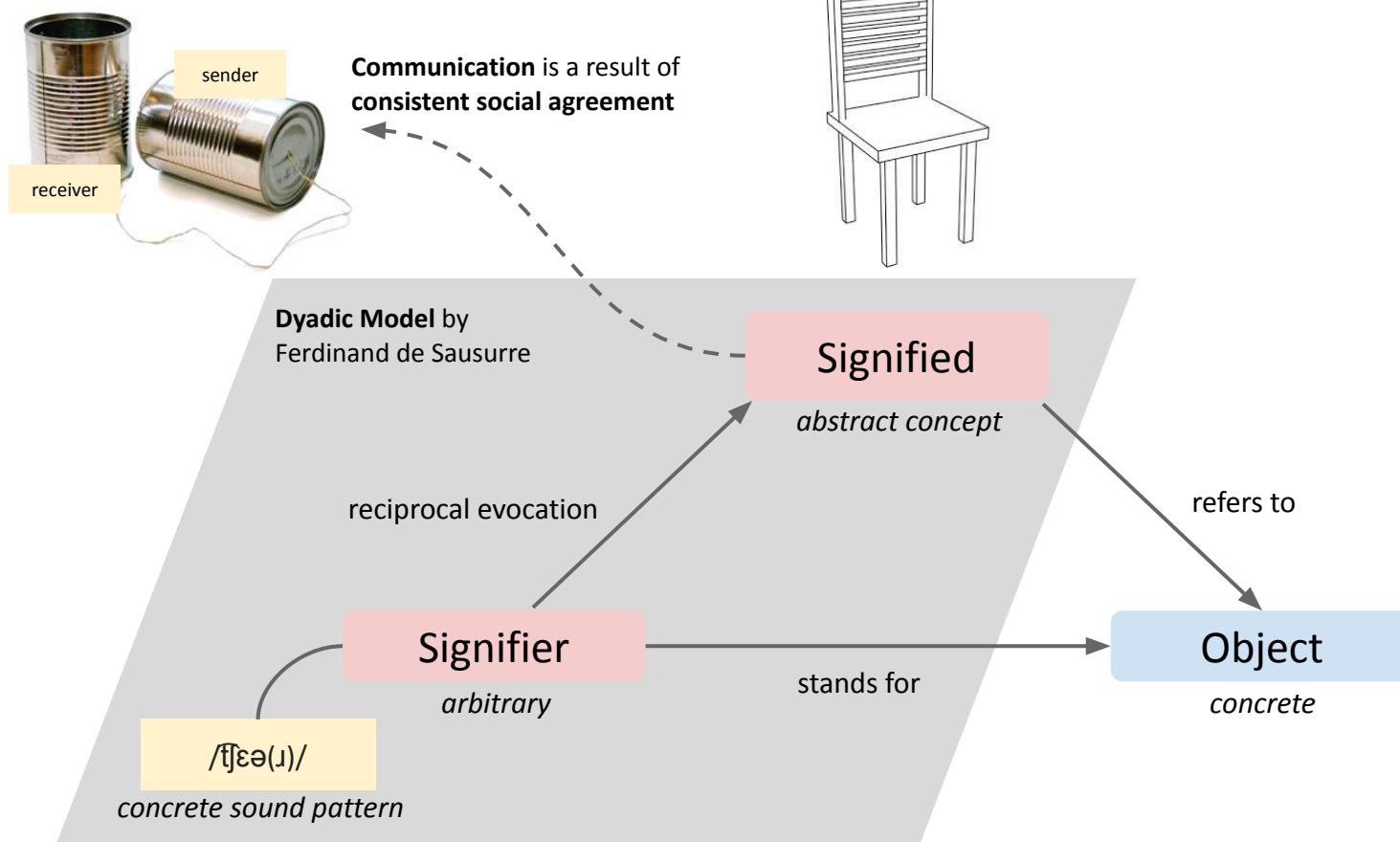
Successful Communication

- For **successful communication**,
 - information has to be correctly transmitted (**Syntax**)
 - the meaning (**Semantics**) of the transmitted information must be interpreted correctly (= **understanding**)
- **Understanding** furthermore depends on
 - the **context** of both sender and receiver and
 - the **pragmatics** of the sender
- **Context** of sender and receiver depend on
 - the **experience** (knowledge of the world) of both sender and receiver

Communication of Meaning



Language and Semiotics



Saussure, Ferdinand de. Course in General Linguistics (1916)

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1. Information, Natural Language and the Web

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1. Information, Natural Language and the Web

Syllabus Questions

- What is a knowledge graph and how do (web) search engines make use of a knowledge graph?
- What is communication?
- What are the differences between natural and artificial languages?
- What does it mean to understand?
- How does information theory measure information?
- What is (information) entropy and how is it computed?
- What are the main challenges for search engines to „understand“ information of the Web?
- What does the correct interpretation of information depend on?
- What is syntax, semantics, context, pragmatics, and experience?
- What is required for successful communication?