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*15° International Conference on Knowledge Management
2° Internatoinal Seminar on Corporate Universities and Government Schools*

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The Third Wave of AI and the Management of Scientific Knowledge

Rosina Weber

OUTLINE

**AI &
DECISION
MAKING**

**THE FIRST
WAVE**

**THE SECOND
WAVE**

**THE THIRD
WAVE**

**MANAGING
SCIENTIFIC
KNOWLEDGE**

TAKE-AWAYS

AI & DECISION MAKING

**AI &
DECISION
MAKING**

The connection between AI and decision making that situates the role of AI in KM

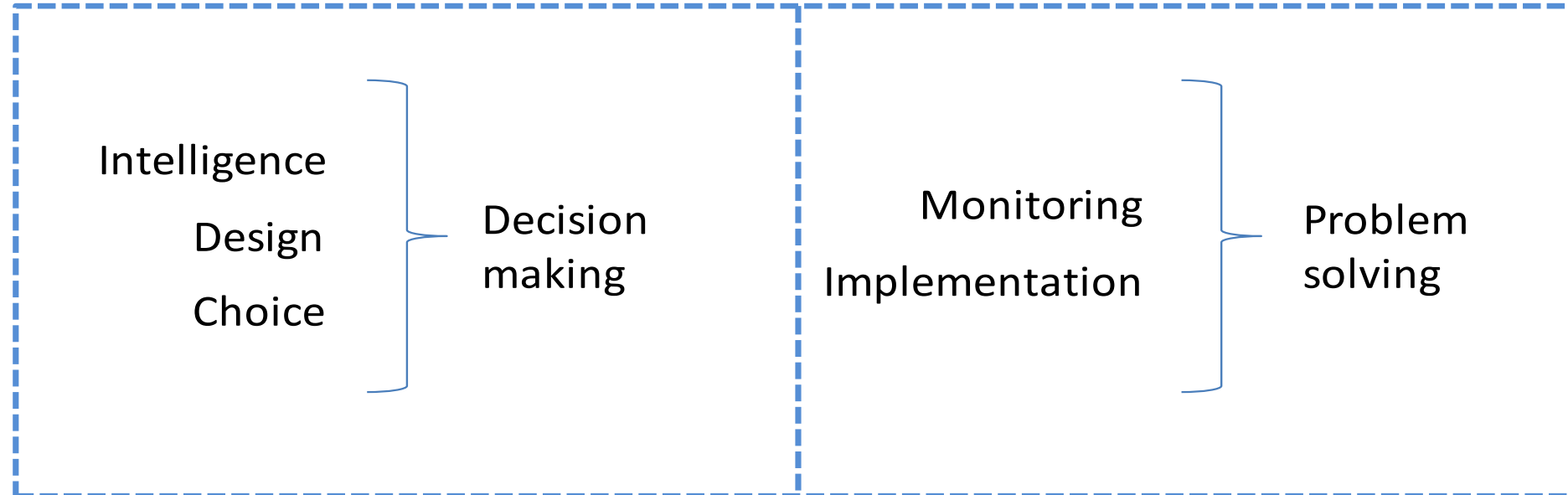


Academics, practitioners

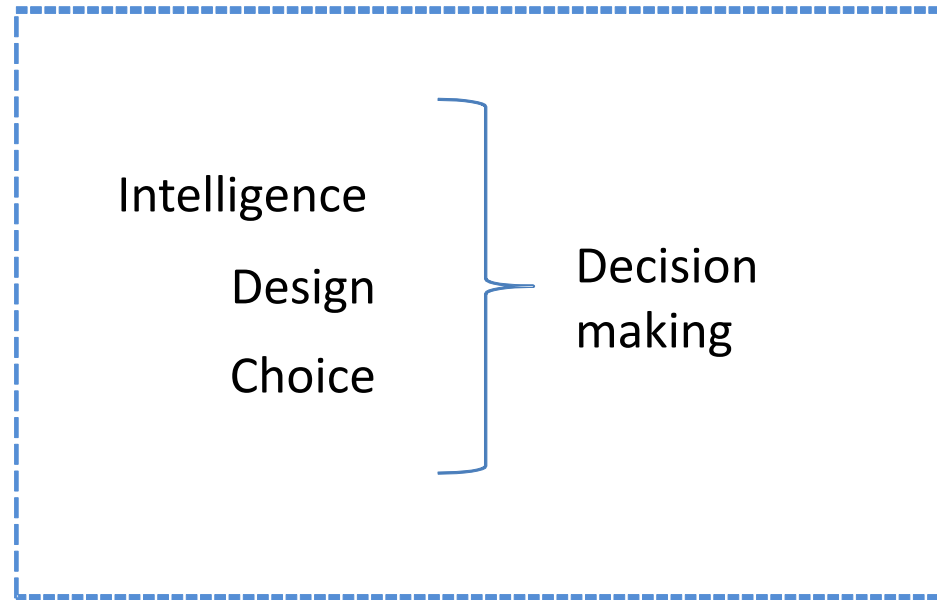
**The future of KM may
depend on us agreeing with
some basic concepts so we
can successfully collaborate**

engineering, computing and social sciences

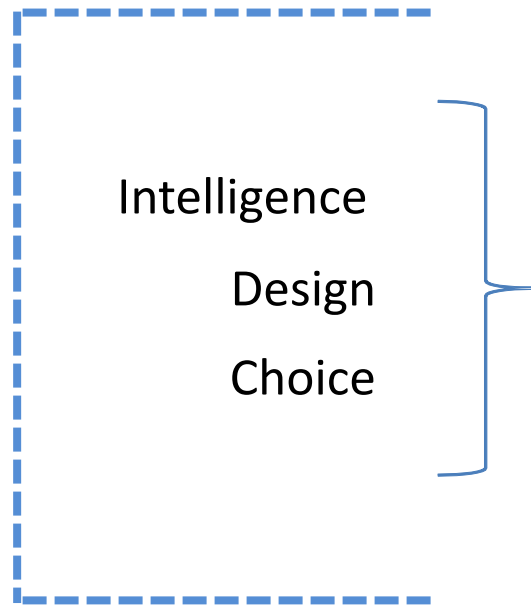
AI & Decision Making



Simplified model of decision-making and problem solving



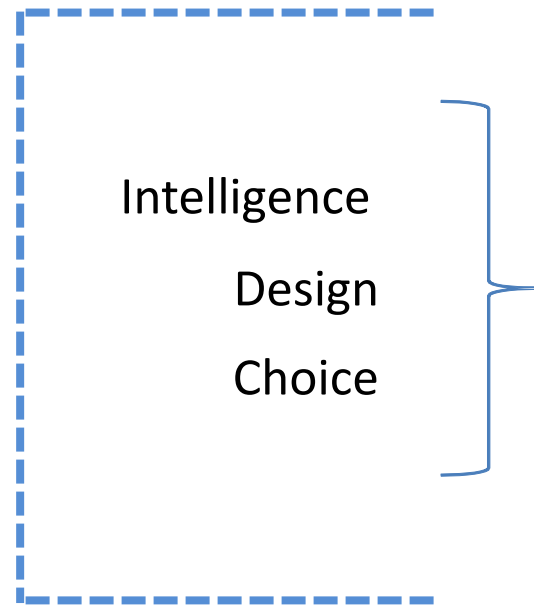
Simplified model of decision-making and problem solving



Intelligence is the gathering of information
Intelligence is fundamental for rational and responsible decision making

**E.g., symptoms of a disease;
salary and starting day**

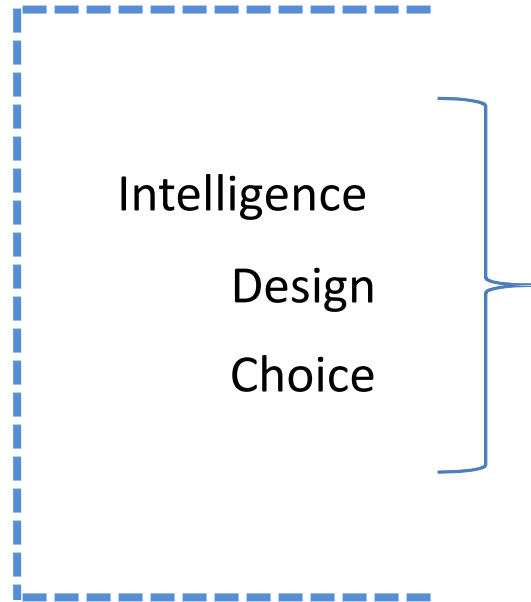
Simplified model of decision-making and problem solving



Design refers to identifying strategies for decision

**E.g., common cold, flu, allergies;
highest salary, oldest starting
day**

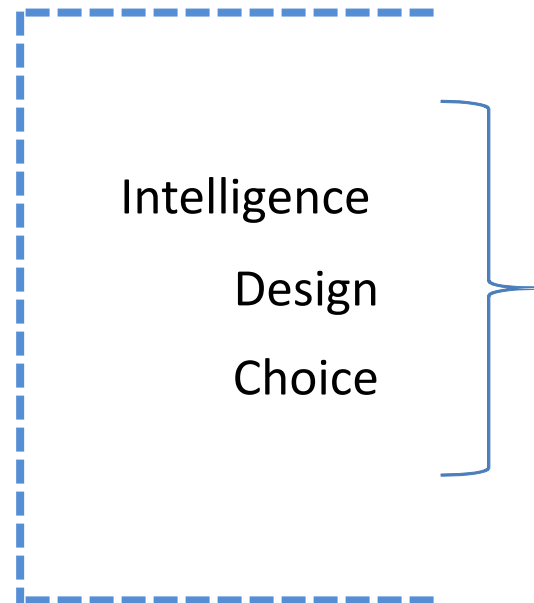
Simplified model of decision-making and problem solving



Choice is on which strategy to adopt for decision

**E.g., allergies;
oldest starting day**

Simplified model of decision-making and problem solving



Intelligence (information)

Design and choice (knowledge)

KM processes have typically targeted these steps

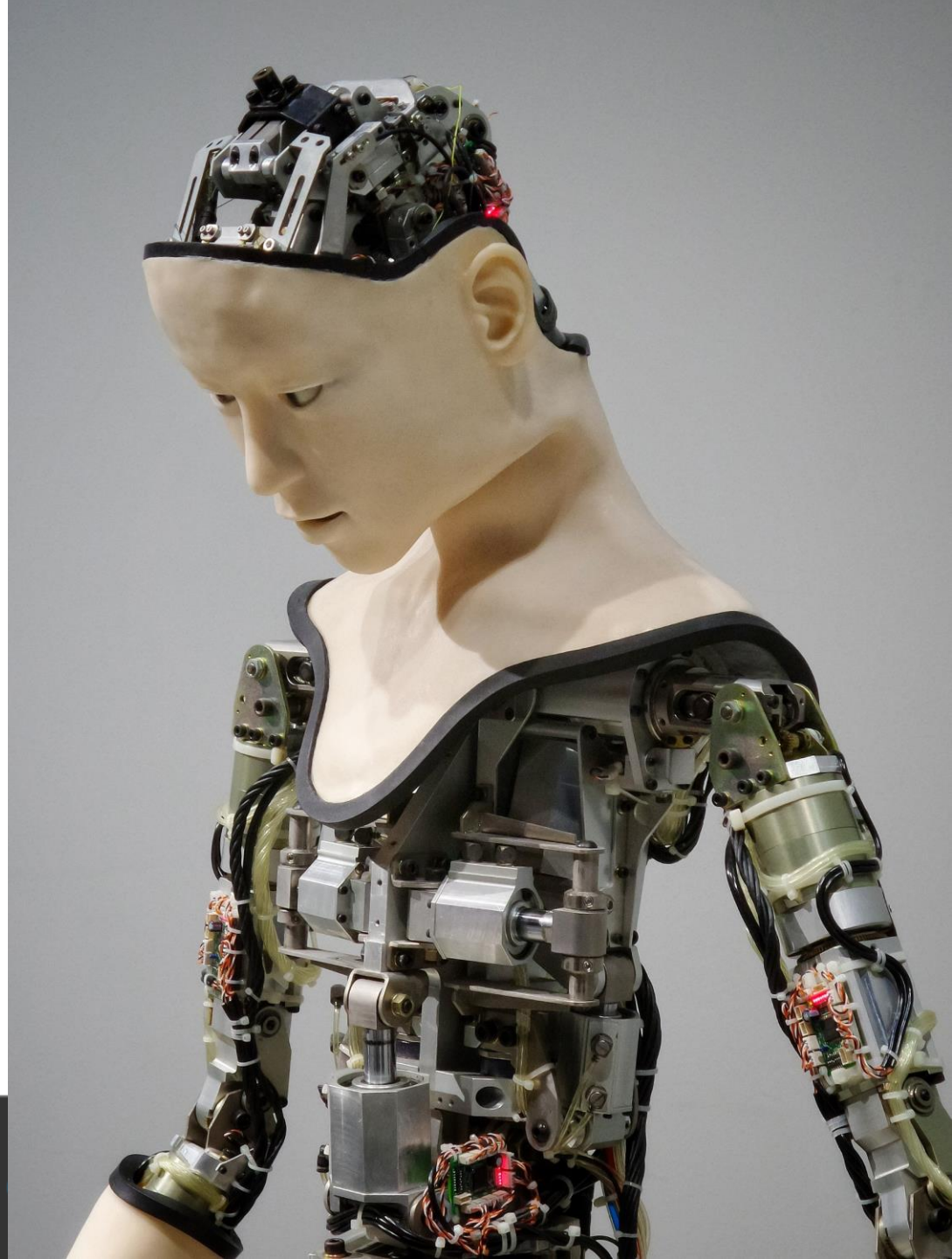
<u>Entity</u>	Intelligence (information)	Design and choice (Knowledge)	
Humans	Obtain information from other humans or from data/databases	Source	Output
		Use knowledge from their minds	Produce elaborate decisions

Intelligent agents are the focus of study of artificial intelligence

Artificial Intelligence

AI is the field of study dedicated to the design and development of intelligent agents, which are software agents that exhibit rational behavior when making decisions.

Intelligent agents agents make decisions as they execute complex tasks such as classification, planning, design, natural language, prediction, image recognition, recommendation, etc.



Three Waves of AI

**Proposed by DARPA,
The Defense Advanced Research
Projects Agency**

Three waves of AI

DESCRIBE

Represented
knowledge

CATEGORIZE

Statistical
learning

EXPLAIN

Uses context
Adapts

OUTLINE

An aerial photograph of a dense urban landscape, likely Hong Kong, with numerous high-rise buildings and a body of water in the background. A white starburst graphic is overlaid on the left side of the image.

**THE FIRST
WAVE**

First Wave

DESCRIBE

Represented
knowledge

Content-based
recommenders

Case-based

reasoning

Sentiment
analysis

Credit underwriting

Robot

navigation

Genetic

Route

algorithms

planning

Natural language processing

Collaborative

Rule-based planning

reasoning Ontologies

Machine translation

Automated

Expert control

systems

Model-

based

Automated

diagnosis

Intelligent

help-desk

Intelligent

tutoring

systems

Creativity

First Wave

DESCRIBE

Represented knowledge

All AI methods that exist today were conceived in the First Wave

The first wave started when the name of the field was coined

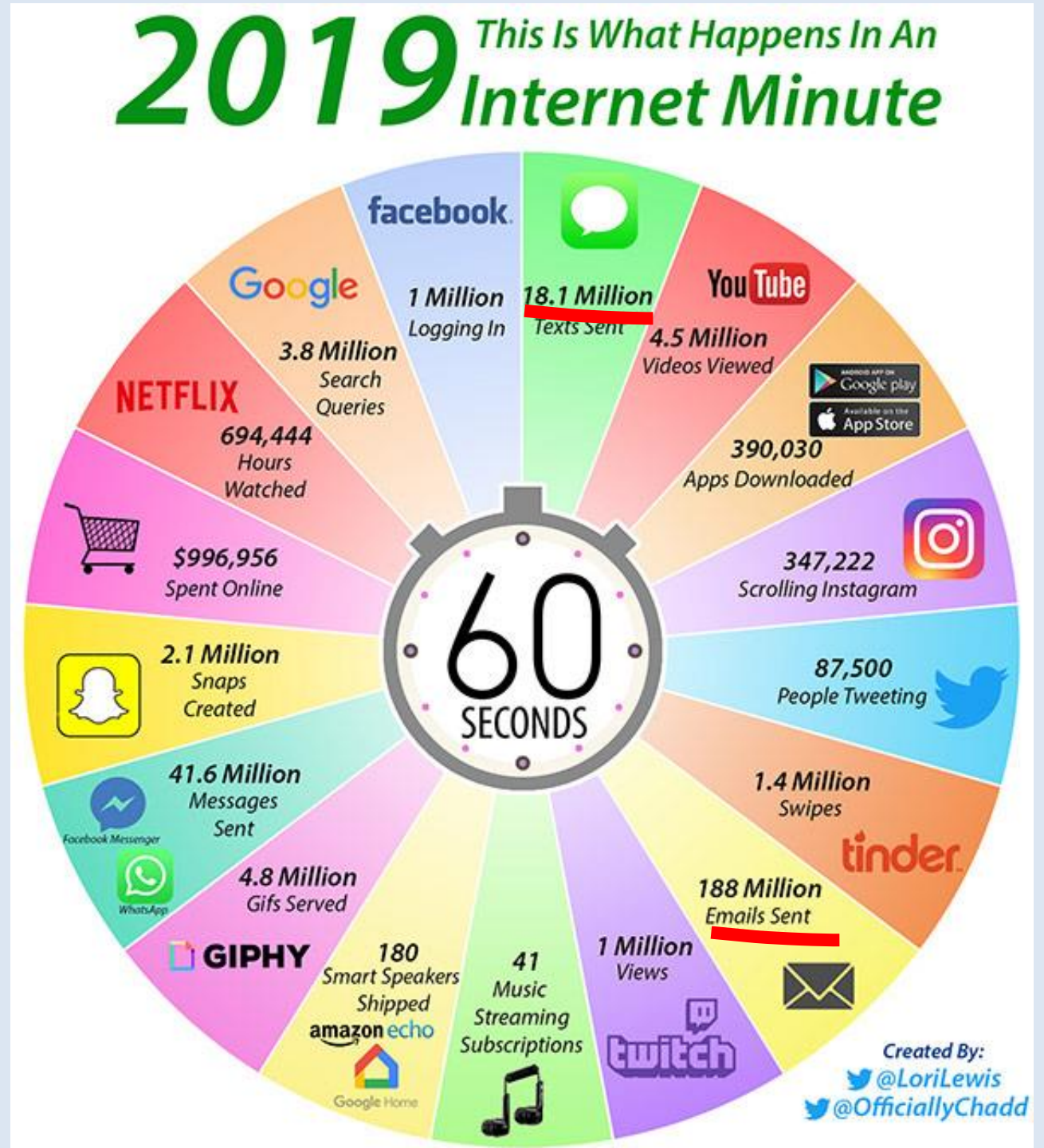
The vision of the field was that if we can represent, then we can replicate

Entity	Intelligence (information)	Design and choice (Knowledge)	
		Source	Output
Intelligent agents from the First Wave of AI	Obtain information from humans through interfaces	Use represented knowledge	Produce decisions as complex tasks

Entity	Intelligence (information)	Design and choice (Knowledge)	
Humans	<u>Other humans or databases</u>	Source	Output
		Knowledge from their minds	Produce elaborate decisions
Intelligent agents from the First Wave of AI	From humans through interfaces	Represented knowledge	Produce decisions as complex tasks

The world changed

The old way to
convert data
into
information
and let
humans make
decisions no
longer works



OUTLINE

**THE SECOND
WAVE**

**Data deluge
can no longer
be absorbed
by databases
processing
information
for humans
to make
decisions**

Second Wave

CATEGORIZE

**Statistical
learning**

**Intelligent
agents are
required to
absorb data
converting it
into decision
making
agents**

Word Cloud containing various machine learning and AI terms:

- Automated diagnosis
- Image reconstruction
- Bayesian learning
- Deep learning
- Pattern recognition
- Data mining
- Categorization
- Machine translation
- Natural language entailment
- Sentiment analysis
- Credit underwriting
- Collaborative recommender systems
- SVM
- Association rule learning
- Citation recommenders
- Image recognition
- Convolutional neural networks
- Binary Classification
- Neural networks
- Dimensionality reduction
- Word embeddings
- Regression
- Speech
- Clustering
- Image segmentation
- Multilabel Classification

Based on <https://www.darpa.mil/work-with-us/ai-next-campa>

Second Wave

CATEGORIZE

Statistical learning

Data deluge is absorbed by data-intensive intelligent agents that build models to make decisions

Intelligent agents are required to absorb data for responsible decision making

Adopting intelligent agents became an important niche for innovation

Every organization is a data organization

Entity	Intelligence (information)	Design and choice (Knowledge)	
Intelligent agents from the Second Wave of AI	From data straight to knowledge	Source	Output
		Create knowledge models	Produce decisions as complex tasks

Entity	Intelligence	Design and choice (Knowledge)	
Humans	Other humans or databases	Source	Output
		Knowledge from their minds	Produce elaborate decisions
First Wave agents	Interfaces	Represented knowledge	Complex tasks
Second Wave agents	Data	Models	Complex tasks*

Second Wave

CATEGORIZE

Statistical
learning

The good news:

Never before AI agents were so accurate and powerful

The bad news:

Humans are uncomfortable in trusting decision making agents

OUTLINE

**THE THIRD
WAVE**

Post hoc XAI
Sensitivity analysis
Lime
Game theory:
explanation
Shapley
goodness
Mental models
Normative
Ethics
agency
Saliency
maps
Transparency
Case-based
Textual XAI
explanation satisfaction
Anchors
compliance
Accountability
eXplainer
Interpretability
Intrinsic
methods
Credit
underwriting

Third Wave

EXPLAIN

Uses context
Adapts

Intelligent agents explain their decisions

Intelligent agents can adapt their decisions to different contexts

Intelligent agents become partners of humans in decision making and learning

Humans supervise the work of multiple decision making agents

Third Wave

EXPLAIN

Uses context
Adapts

Entity	Intelligence	Design and choice (Knowledge)	
Intelligent agents from the Third Wave of AI	From data, big data, information, human feedback, user models, user goals, user plans, context, ...	Source	Output
		All waves combined and humans	Produce decisions and explanations in collaboration with humans to satisfy end users, earn trust, be ethical and accountable

Entity	Intelligence	Design and choice (Knowledge)	
Humans	Other humans or databases	Source	Output
		Their minds	Elaborate decisions
First Wave agents	Interfaces	Represented knowledge	Complex tasks
Second Wave agents	Data	Models	Complex tasks*
Third Wave agents	Data, big data, information, ..	All waves & humans	Decisions that satisfy human needs

OUTLINE

**MANAGING
SCIENTIFIC
KNOWLEDGE**

Scientific knowledge resides in scholarly data



Scientific knowledge in scholarly data

Subset of knowledge available out there

Roughly 200 million scientific articles electronically available

For which there are no means for humans alone to absorb

It is important that we are able to know what is out there

Computing Support Literature Reviews

Majority of research in automating literature reviews target summaries (e.g., [Qazvinian](#)).

How can anyone trust a summary drafted of a literature review if the steps and explanations are not transparent?

Existing Tools Supporting Literature Search

Citation recommendation vs. Academic information retrieval

Input is a text

Recommended citation is explained

Third Wave Solution

Explain why users should incorporate a given citation into their review

WEBER ET AL. 2018 IS AN
ESSENTIAL CITATION BECAUSE
YOU PARAPHRASED THEIR WORK
IN YOUR QUERY TEXT

Now that
makes
sense!



Managing Knowledge in the Third Wave

The explanation/substantiation of a complex task may be external to the intelligent agent that proposes the decision

As long as the explanation is aligned with the agent making the decision

It is part of the decision

Getting to Elaborate Decisions

The knowledge may be out there, It may be still in data form

It may be buried in scientific publications

This is also a KM task because it supports decision making

OUTLINE

TAKE-AWAYS

Intelligent agents need KM

What distinguishes an elaborate decision given by a human from the result of a complex task provided by an intelligent agent is today referred to as explanation

Bringing them to a decision is knowledge management

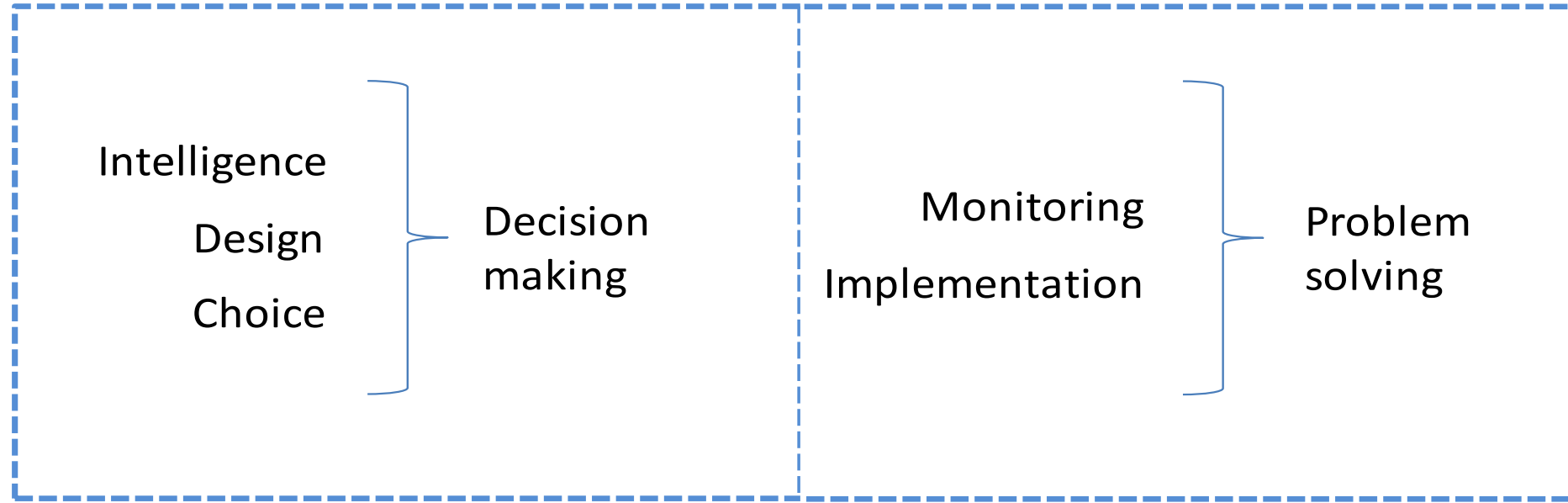
Take-aways

There are no means for humans alone to absorb all that is around us

All the data, all the information, and all the knowledge that may be buried in it

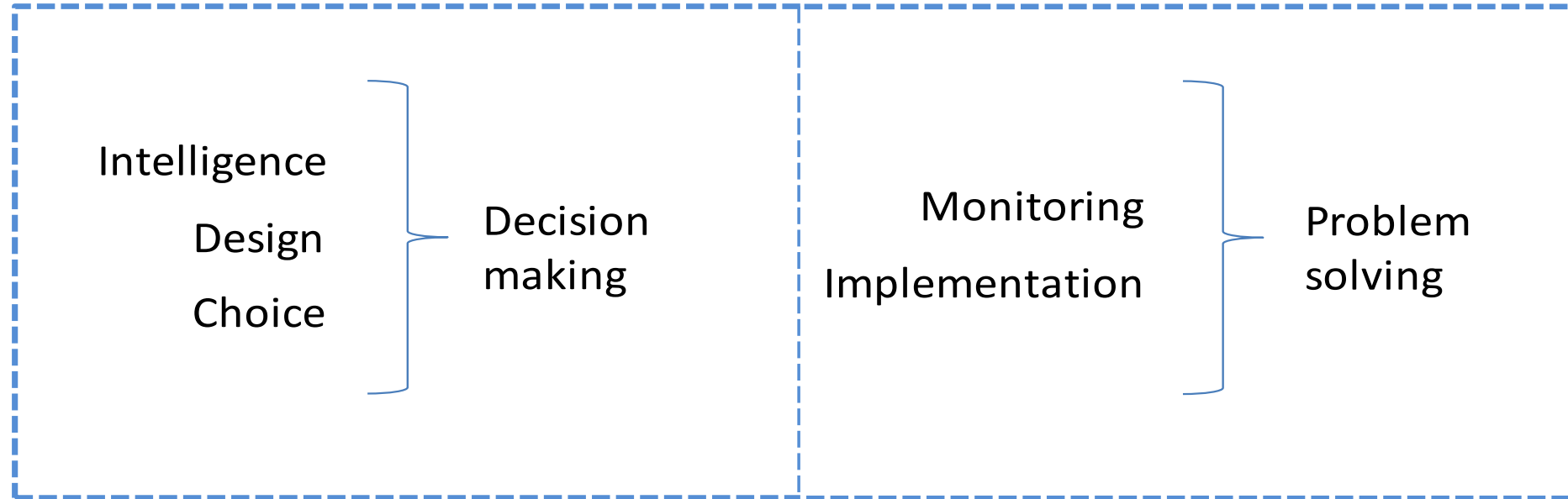
To make responsible decisions, it is necessary to get the help of intelligent agents

AI & Decision Making



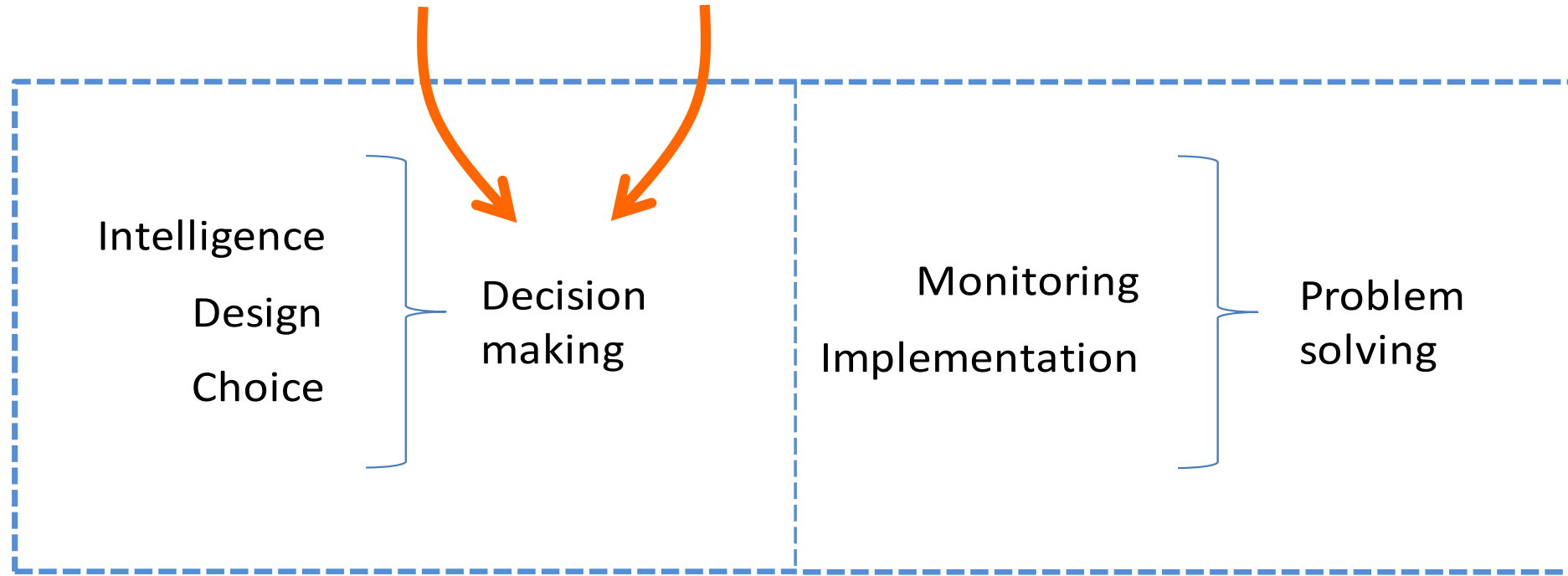
Simplified model of decision-making and problem solving

AI & Decision Making



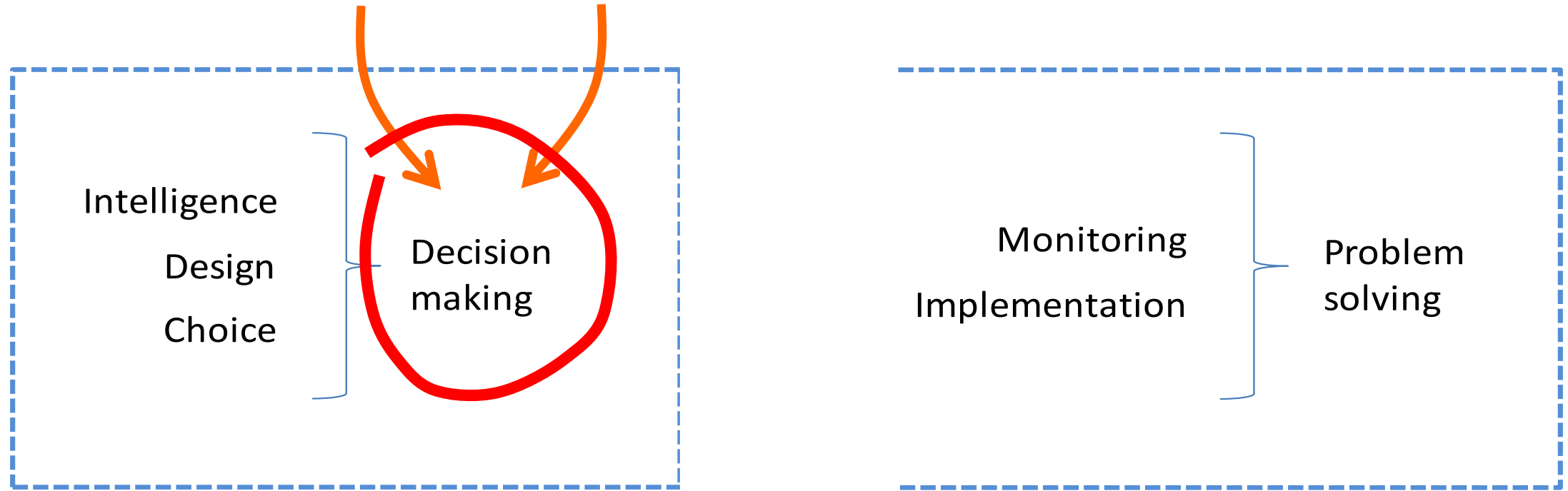
Decision making and problem solving have been usually done by the same entity

KM tasks, e.g. knowledge sharing has usually targeted humans at the decision making step



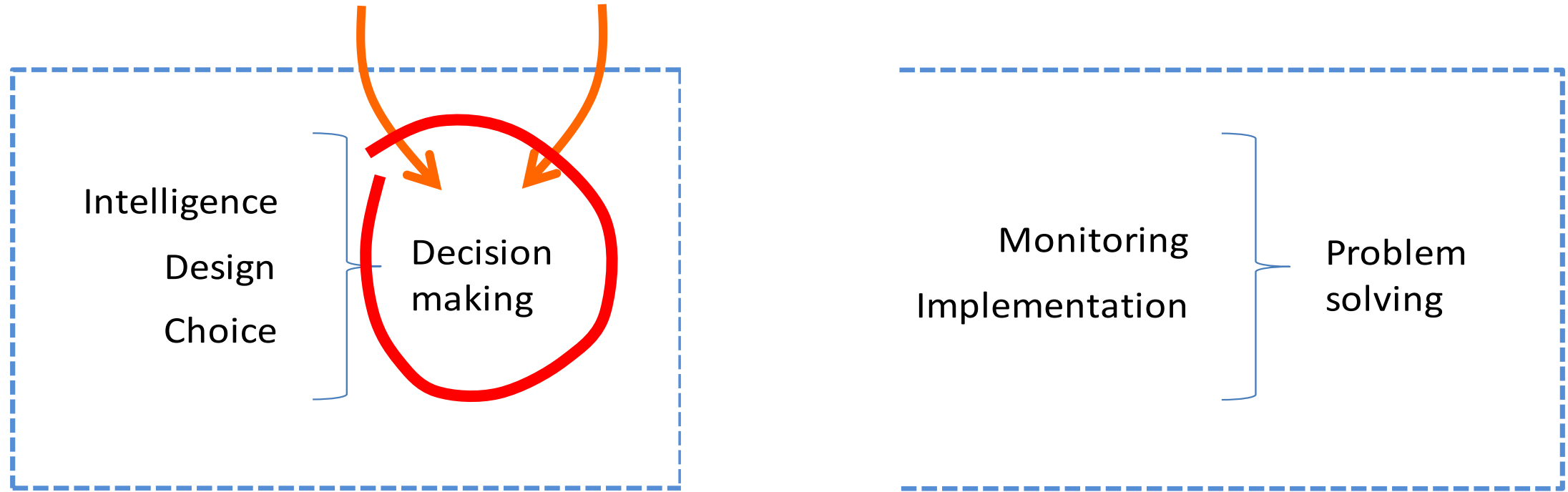
Decision making and problem solving have been usually done by the same entity

Decision making and problem solving may be done by different entities



Is the science of KM ready to share knowledge with intelligent agents?

How well have we done by targeting the decision making step?



Should KM target the entire problem solving step?

Challenges for KM (i)

Just like with humans

Knowledge has to be shared with decision making agents when it is needed, in the context where it is to be reused

Challenges for KM (ii)

Learning from data and building decision making agents that humans can supervise

Challenges for KM (iii)

Decision making is an intermediary step to problem solving

Targeting problem solving may increase the impact of KM

The overall challenge and vision: The realization of the third wave

Humans supervise automated agents that are partners in decision making

Automated agents can explain their decisions, adapt to specific contexts, learn from experience, adopt ethical principles, comply with regulations, and effectively solve problems

Interdisciplinary challenge



Academics, practitioners

**The future of KM may
depend on us agreeing with
some basic concepts so we
can successfully collaborate**

engineering, computing and social sciences



The goal is to foster and obtain mutual trust

Radical shift on the nature of work



References

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Acknowledgements

My students and co-authors

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rosina @ drexel dot edu
Twitter @ai_curious
iMessage rosinaweber@gmail
Skype rosinaweber



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