

# From Representation to Mediation: Modeling Information Systems in a Digital World

## *Keynote Lecture*

Jan Recker, University of Hamburg





## Conceptual Model Evaluation. Towards more Paradigmatic Rigor

Jan Recker<sup>1</sup>

<sup>1</sup> Centre for Information Technology Innovation  
Queensland University of Technology  
126 Margaret Street, Brisbane QLD 4000, Australia  
j.recker@qut.edu.au

**Abstract.** Information Systems (IS) research has so far been primarily concerned with the development of new modeling languages, techniques, and methods. Also, evaluation approaches have been developed in order to assess the appropriateness of a modeling approach in a given context. Both modeling and evaluation approaches, however, lack epistemological rigor, leading to problems regarding the applicability of a certain modeling language in a given context on the one hand, and regarding the feasibility of certain evaluation approaches towards certain modeling questions on the other hand. We therefore argue for a philosophical-paradigmatic discussion of evaluation methods for conceptual modeling languages in order to assess their applicability in given modeling contexts and present our research in progress towards a framework for paradigmatic discussion on model evaluation.

**Keywords.** Philosophy, modeling methods, information modeling, research evaluation

### 1 Introduction

The importance of information systems (IS) for successful businesses is widely recognized [1]. Their implementation is preceded by their development through design methodologies which utilize information models to specify IS on a conceptual level. Such conceptual models have been successfully employed throughout IS theory and practice. This has led, however, to the proliferation of an enormous amount of available modeling approaches. The "flooding" of the IS discipline with a multiplicity of conceptual modeling approaches consequently leads to an immanent need for comparing and evaluating existing modeling methods in order to determine which approach is most appropriate for a given modeling task. While evaluation approaches for conceptual modeling languages do exist, e.g. [2, 3], they differ substantially in method and approach. Thus, the question remains, which evaluation approach is most appropriate for finding an appropriate answer in a given situation. An objective of this research is to develop an approach to compare different evaluation approaches for conceptual models in order to explicate their applicability and appropriateness for modeling questions.

## Proceedings of the CAiSE'05 WORKSHOPS Vol. 1

BPMDs • DIQ • DISWeb  
EMMSAD • SWWL

Jaelson Castro, Ernest Teniente (Eds.)

The 17th Conference on Advanced Information  
Systems Engineering  
13-17 June 2005  
FEUP, Porto, Portugal  
Revised Papers

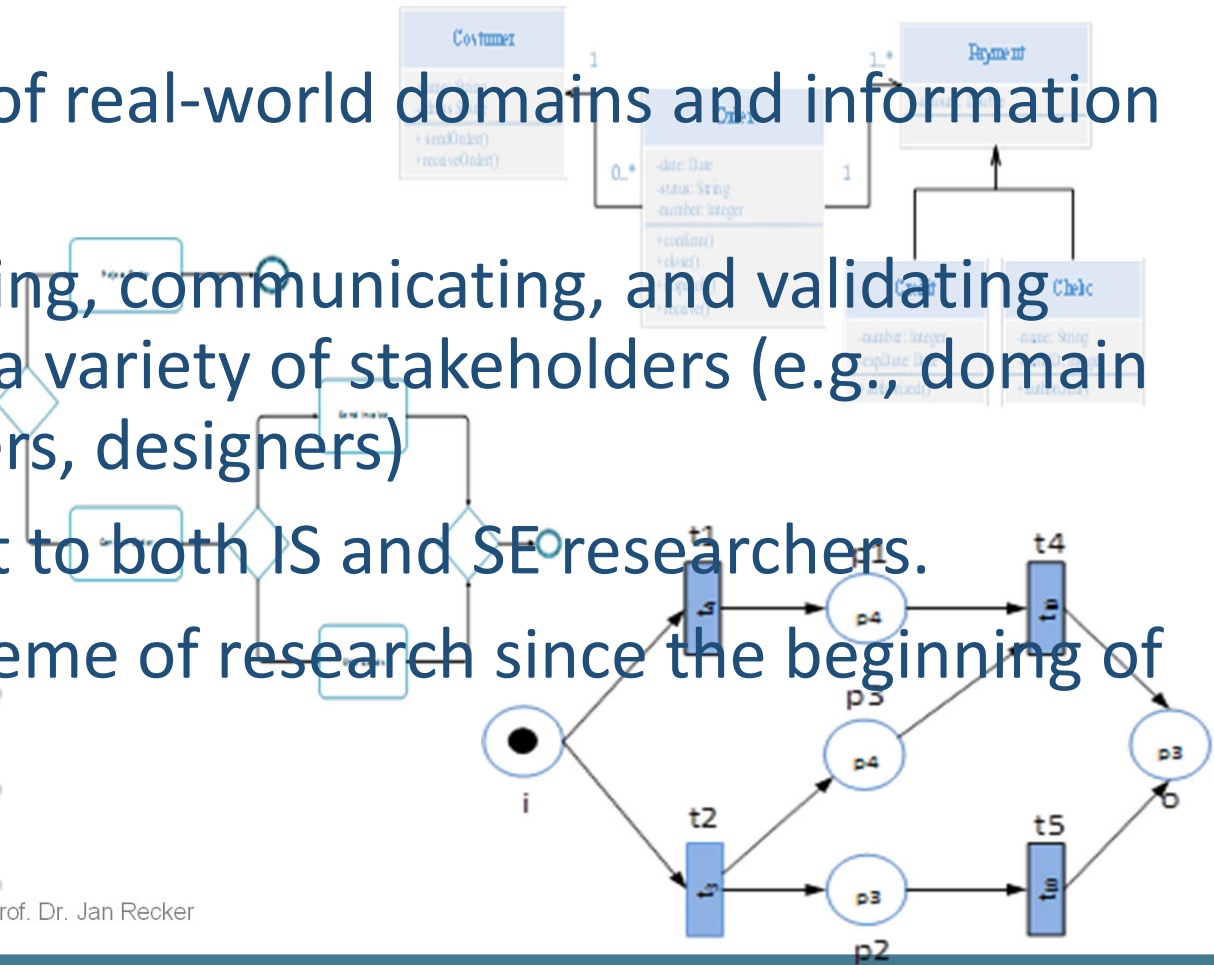
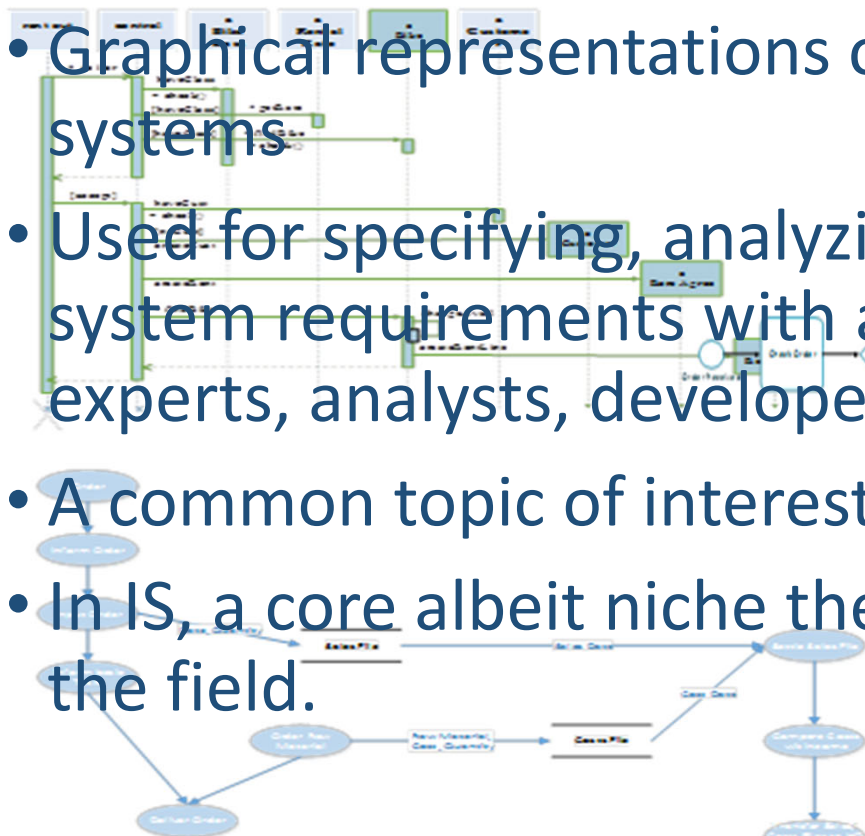


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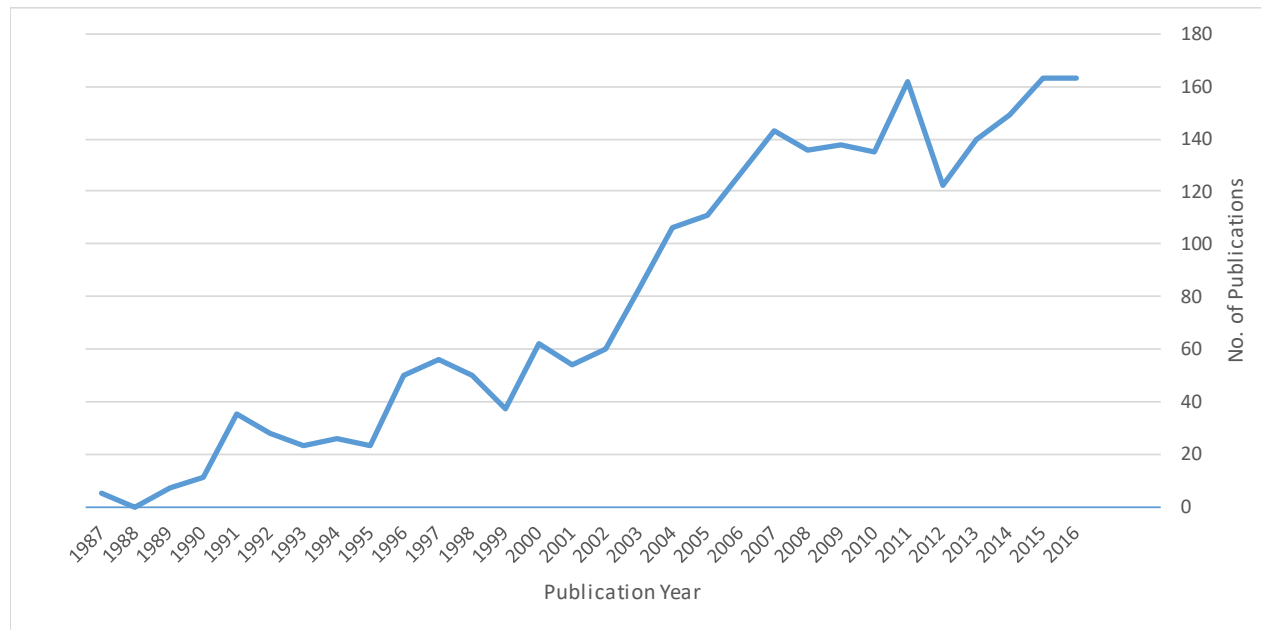
**Is what we know about  
*systems analysis,*  
*specification, design, and*  
*development* consistent  
with what is going in the  
real world?**

# Conceptual Models

- Graphical representations of real-world domains and information systems
- Used for specifying, analyzing, communicating, and validating system requirements with a variety of stakeholders (e.g., domain experts, analysts, developers, designers)
- A common topic of interest to both IS and SE researchers.
- In IS, a core albeit niche theme of research since the beginning of the field.



# Conceptual modeling has been a core part of information systems analysis, specification, and development for some 40+ years.



Topic search ("conceptual modeling" OR "conceptual modelling") on Thomson Reuters Web of Science Core Collection, which revealed 1,796 publications in English from 1987 to 2016.

# At the same time, conceptual modeling research may be dying.

*“The topic of conceptual modeling lacks the appeal of research on emerging technologies (because it is deemed to be an old-technology problem).... Thus, young scholars, in particular, have shied away from the topic.”*

Wand, Y., & Weber, R. (2017). Thirty Years Later: Some Reflections on Ontological Analysis in Conceptual Modeling. *Journal of Database Management*, 28(1), 1-17.

*“Conceptual modelling research is rightfully under constant scrutiny in terms of its validity, applicability, relevance and utility in our ever-changing world.”*

Recker, J. (2015): Research on Conceptual Modelling: Less Known Knowns and More Unknown Unknowns, Please. *11th Asia-Pacific Conference on Conceptual Modelling*, pp. 3-7. Sydney, Australia: Australian Computer Society.



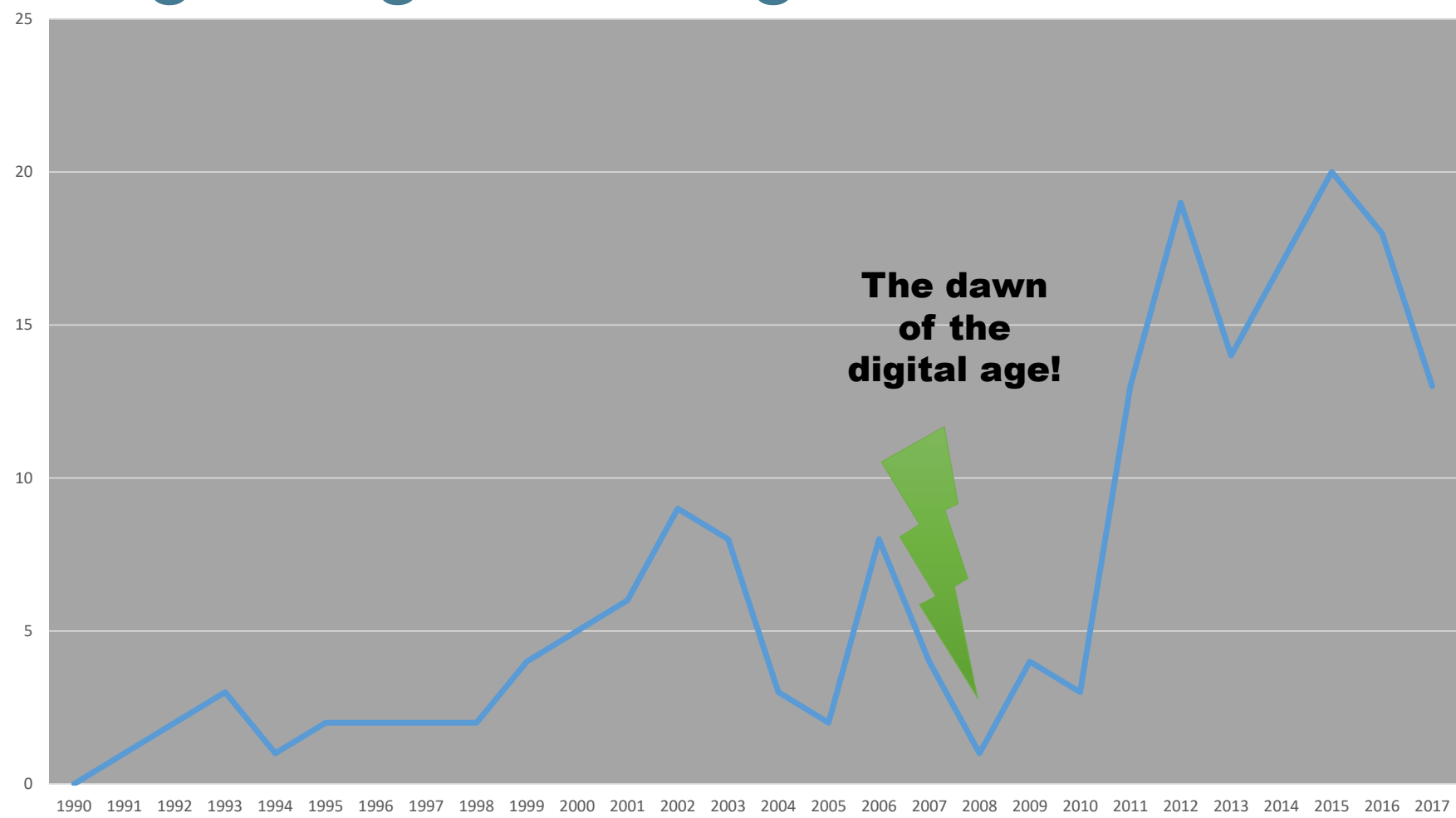
# Conceptual modeling researchers are unsure about their place.

- On September 20, 2018, a message from one of the senior scholars active in conceptual modeling was posted to the AIS SIG SAND community, asking “*how to make the field [...] relevant in the world of Big Data, Cybersecurity, AI, Machine Learning, etc.*”
- Responses posted to this question were strikingly inconsistent:
  - *I think most SIGSAND members see [the topic] at the core of the IS field. However, others in the discipline see it as a peripheral or marginal topic*
  - *“We just need to promote more, provide more ideas, in hot areas [...] then we can encourage new blood to work on it.”*

**What happened?**



# The digital age has begun.





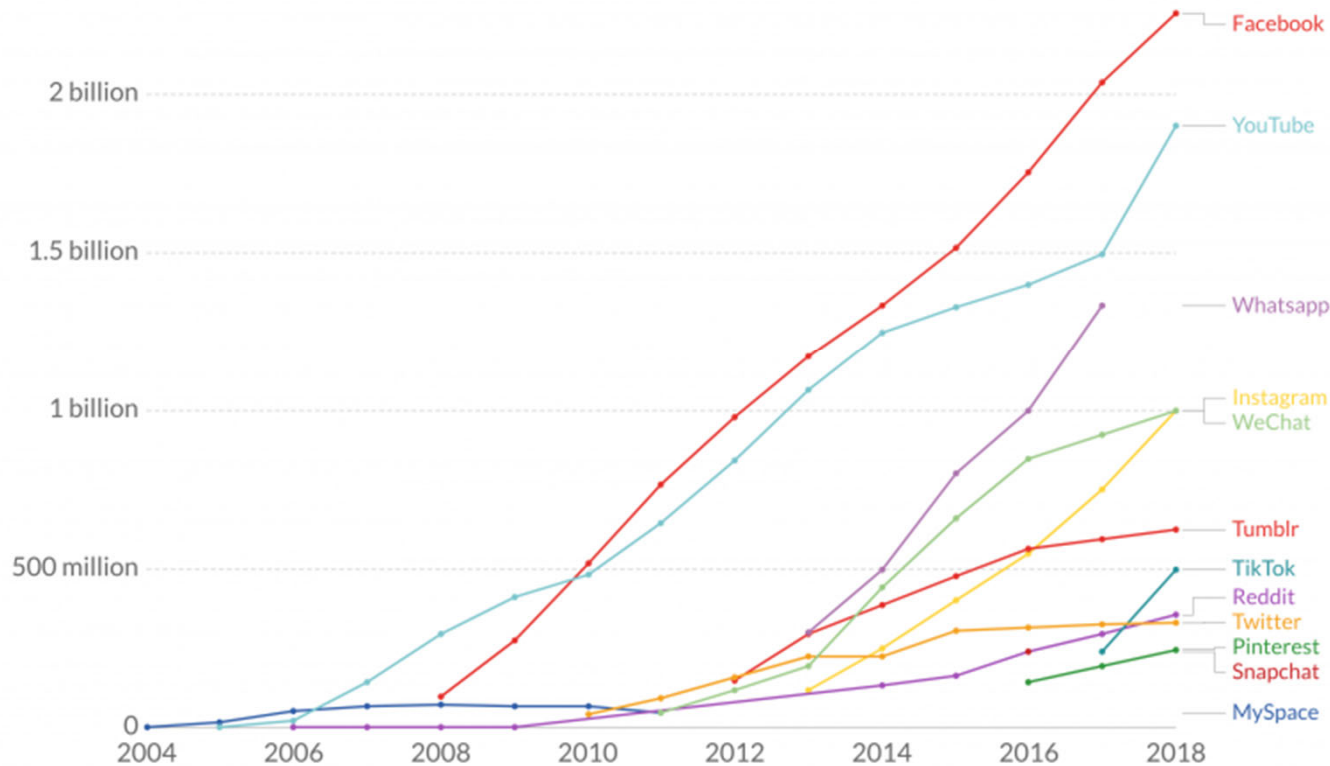
# What happened?



# What happened?

## Number of people using social media platforms

Estimates correspond to monthly active users (MAUs). Facebook, for example, measures MAUs as users that have logged in during the past 30 days. See source for more details.



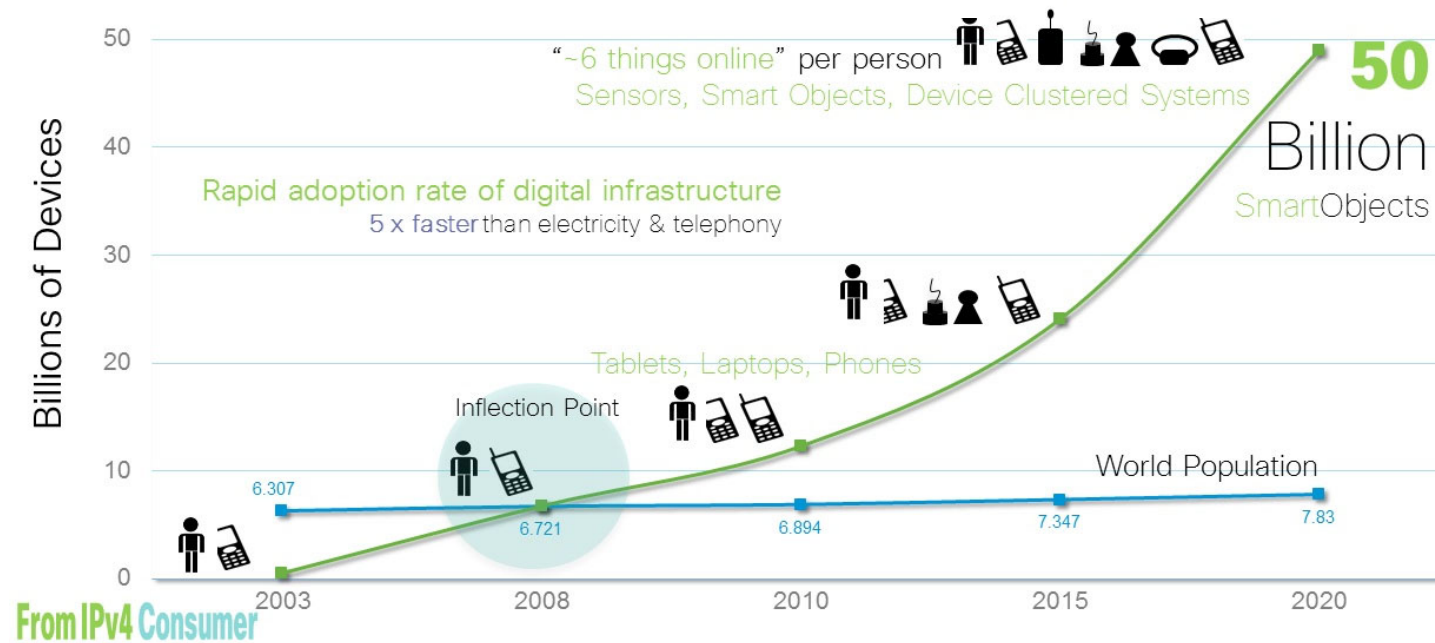
Source: Statista and TNW (2019)

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<https://ourworldindata.org/rise-of-social-media>

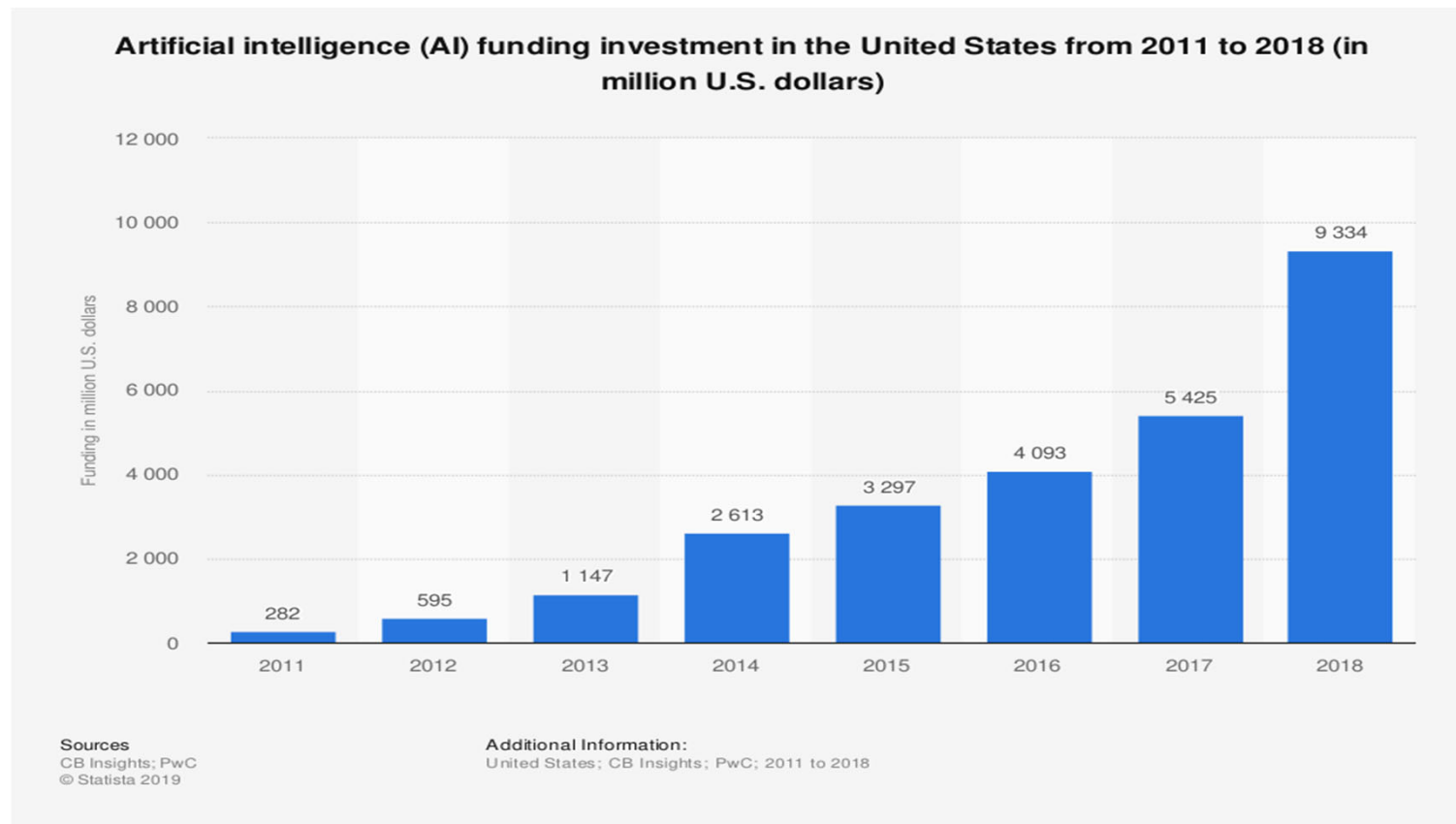


# What happened?



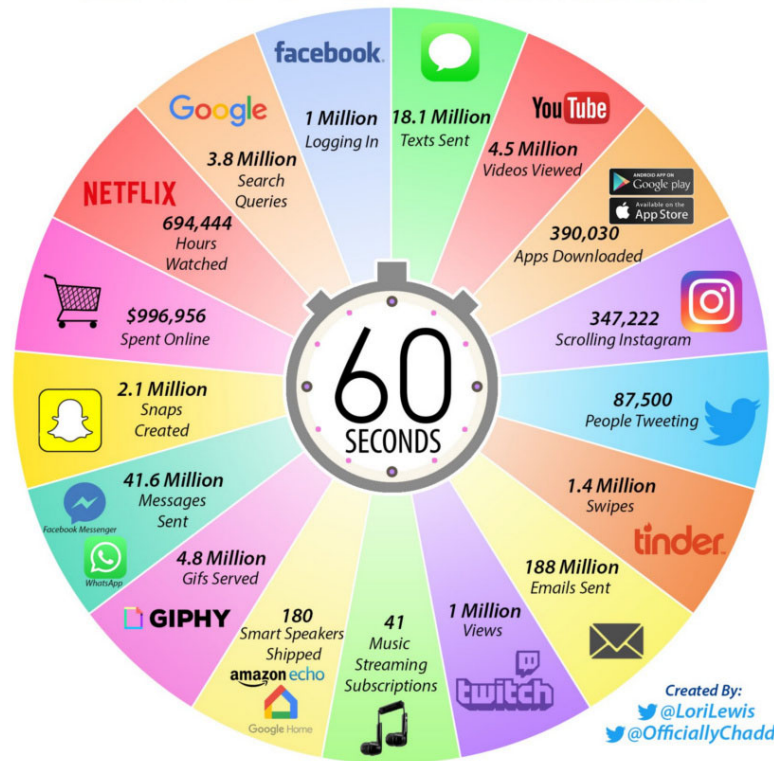
Source: Cisco IBSG projections, UN Economic & Social Affairs <http://www.un.org/esa/population/publications/longrange2/WorldPop2300final.pdf>

# What happened?



# What happened?

## 2019 *This Is What Happens In An Internet Minute*

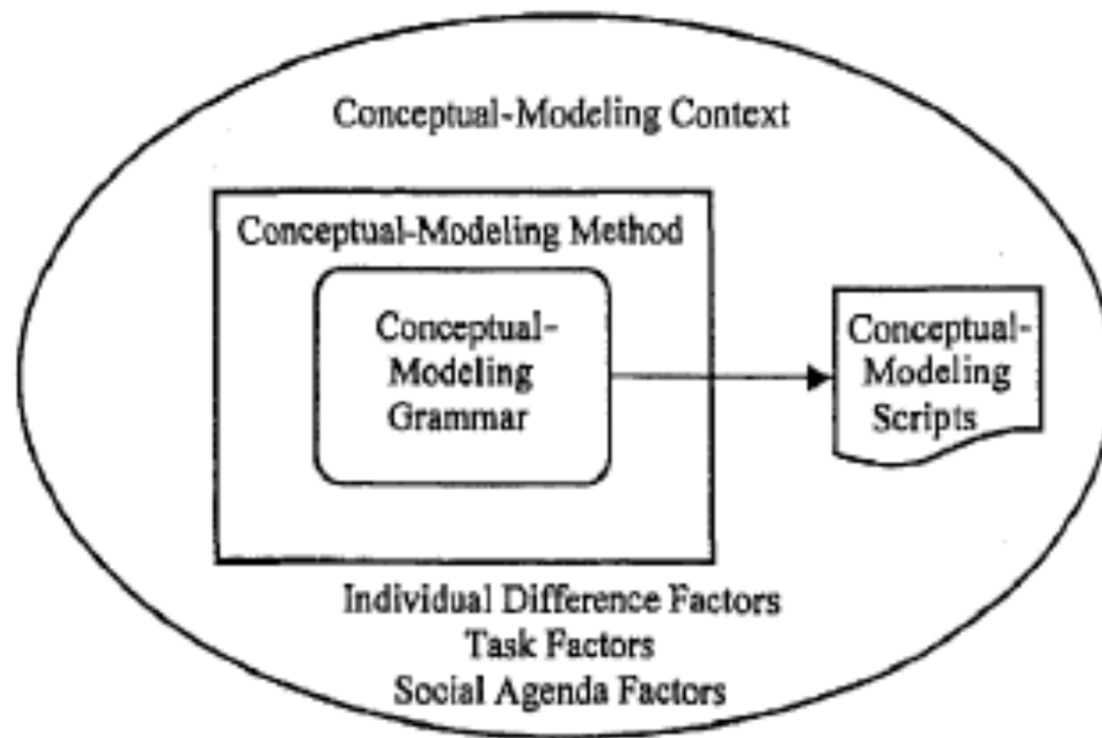


<https://www.visualcapitalist.com/what-happens-in-an-internet-minute-in-2019/>

# The Dawn of the Digital Age

- Smart devices (phones, tablets, watches, etc.) are widely adopted.
- Social networking platforms proliferate and connect billions of users.
- Digital objects overtake humans in terms of population.
- Investments into artificial intelligence and “smart” things.
- Exponential data growth.





Wand, Y., & Weber, R. (2002). Research Commentary: Information Systems and Conceptual Modeling - A Research Agenda. *Information Systems Research*, 13(4), 363-376.

# The world has changed but CM research has not.

- Movements like Agile Development (Fowler & Highsmith, 2001) and DevOps (Wiedemann et al., 2019) have changed modeling and documentation practices during systems analysis and design.
- Technological developments like NoSQL databases, machine learning, and business analytics challenge the form, function, and utility of relational databases (Storey & Song, 2017).
- The ongoing infusion of digital technologies into economic goods and everyday artifacts blurs the boundaries among the surface, physical, and deep structures of IS.
- Actions and decisions taken in a digital reality increasingly influence those in physical reality (Baskerville et al., 2020).
- Collective action movements like open source development (Bagozzi & Dholakia, 2006), citizen science (Levy & Germonprez, 2017), and crowdsourcing (Majchrzak & Markus, 2013) increasingly involve non-specialist users in IS development.

# “Digital First”: Digital models exist prior to the real-world object.

The Sydney Morning Herald

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## Walmart is redesigning its stores. This is what they'll look like


By Jordan Valinsky, CNN Business  
Updated 15:44 GMT (23:44 HKT) September 30, 2020



**TOP STORIES**

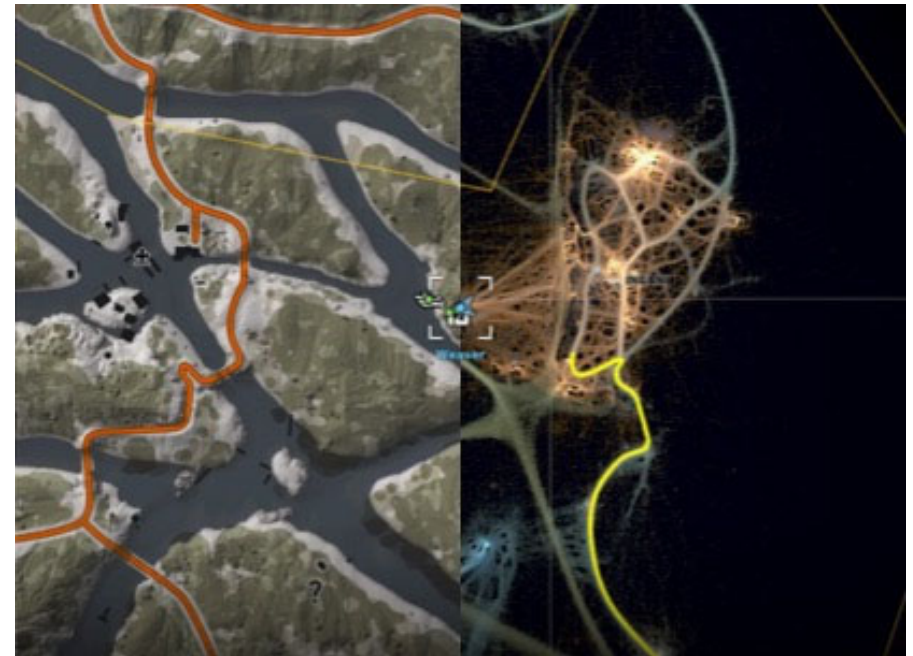
- Four arrested after Black man's body found burning in a ditch in Iowa
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# Data-driven, algorithmic product design

Source: © Ubisoft



Werder, K., Seidel, S., Recker, J., Berente, N., Kundert-Gibbs, J., Abboud, N., & Benzeghadi, Y. (2020). Data-Driven, Data-Informed, Data-Augmented: How Ubisoft's Ghost Recon Wildlands Live Unit Uses Data for Continuous Product Innovation. *California Management Review*, 62(3), 86-102.



# Conceptual models of pizzas.



# CM research has not kept up with the world.

- We reviewed all CM work in the Basket-of-8 journals plus JDM, Inf. Systems, and IEEE TSE between 2002 and 2016.

Recker, J., Lukyanenko, R., Jabbari Sabegh, M. A., Samuel, B. M., & Castellanos, A. (2021). *From Representation to Mediation: A New Agenda for Conceptual Modeling Research in a Digital World*. **MIS Quarterly**, 45(1), 269-300. Available open access at <https://doi.org/10.25300/MISQ/2020/16207>.

Journals	Initial search results	Papers retained after screening	Papers included in review
Journal of the Association for Information Systems	500	18	18
European Journal of Information Systems	527	19	15
Information Systems Research	261	18	9
MIS Quarterly	659	6	6
Information Systems Journal	360	8	5
Journal of Strategic Information Systems	199	3	2
Journal of Management Information Systems	582	6	1
Journal of Information Technology	265	2	1
IEEE Transactions on Software Engineering	416	58	54
Journal of Database Management	326	53	49
Information Systems	127	46	37
<u>Total</u>	<u>4,222</u>	<u>237</u>	<u>197</u>

# Some summative findings

CM Element in Focus	Papers	
	#	%
Grammar	20	10.15
Method	41	20.81
Script	11	5.58
Context	14	7.11
Grammar and Method	8	4.06
Grammar and Script	7	3.55
Grammar and Context	4	2.03
Method and Script	10	5.08
Method and Context	16	8.12
Script and Context	7	3.55
Grammar, Method, and Script	1	0.51
Method, Script, and Context	2	1.02
Grammar, Script, and Context	4	2.03
Elements other than those highlighted by Wand and Weber (2002).	52	26.40
<b>Total</b>	<b>197</b>	<b>100.00</b>

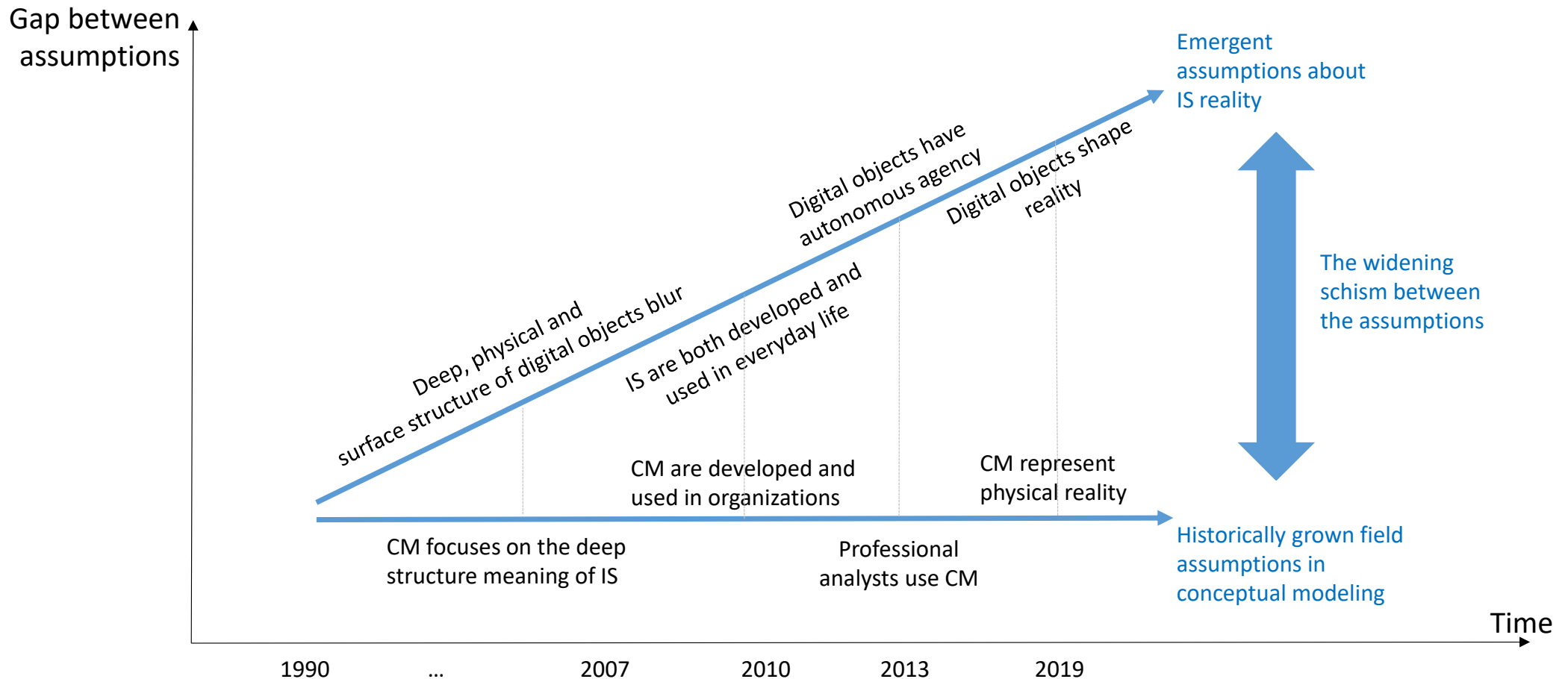
Grammar	#	Grammar	#
UML	38	ER	28
Specific UML grammar	32	Petri nets	13
• Class	15	BPMN	12
• Use Case	7	EPC	8
• Activity	7	Extended ER	7
• State Machine	5	Workflow	4
• Sequence	4	ANSI Flowchart	3
• Collaboration	2	DFD	2
• Profile	2	YAWL	2
MibML, ISO TC87, Merise, ebXML, BPML, WSCL, WS-BPEL, DEMO, ProH, REA, ORM, IFO, FDM, SDM, NIAM, OMT, OML			1

# Most Popular Research Topics

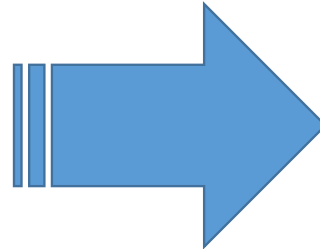
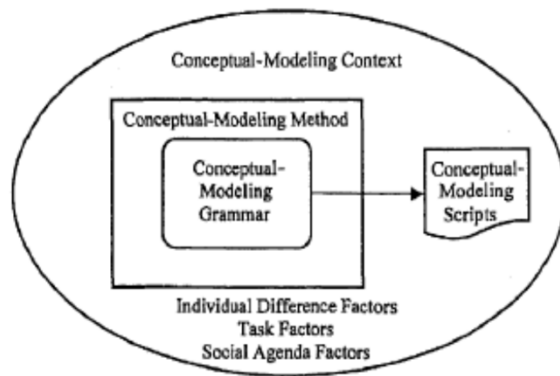
Code	Topic	Number of papers
S1	<b>Evaluating competing scripts generated via the same grammar</b> to describe some phenomenon	21
M2	<b>Developing procedures to assist users of a grammar</b> in identifying and classifying phenomena according to the grammar's constructs	19
CI2	Predicting which <b>cognitive and personality variables</b> bear on a user's ability to undertake conceptual- modeling work	15
G7	Empirically testing the predicted implications of <b>construct deficit and overload</b> in grammars	10
M1	Evaluating how well <b>different methods</b> allow users to elicit and model critical domain knowledge	9



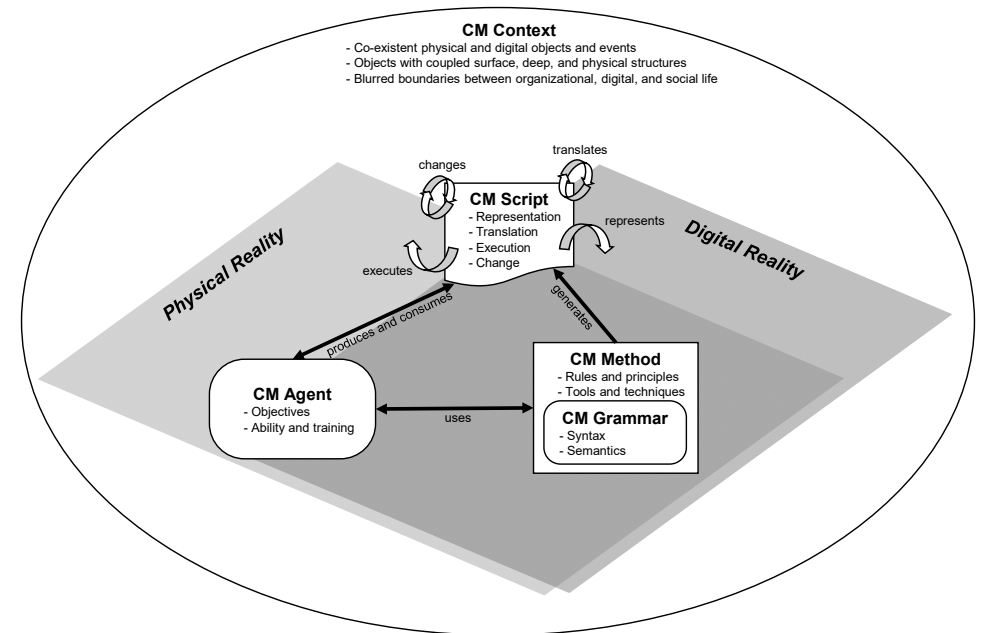
# The schism between research and reality is widening



# We need a new path for CM research.



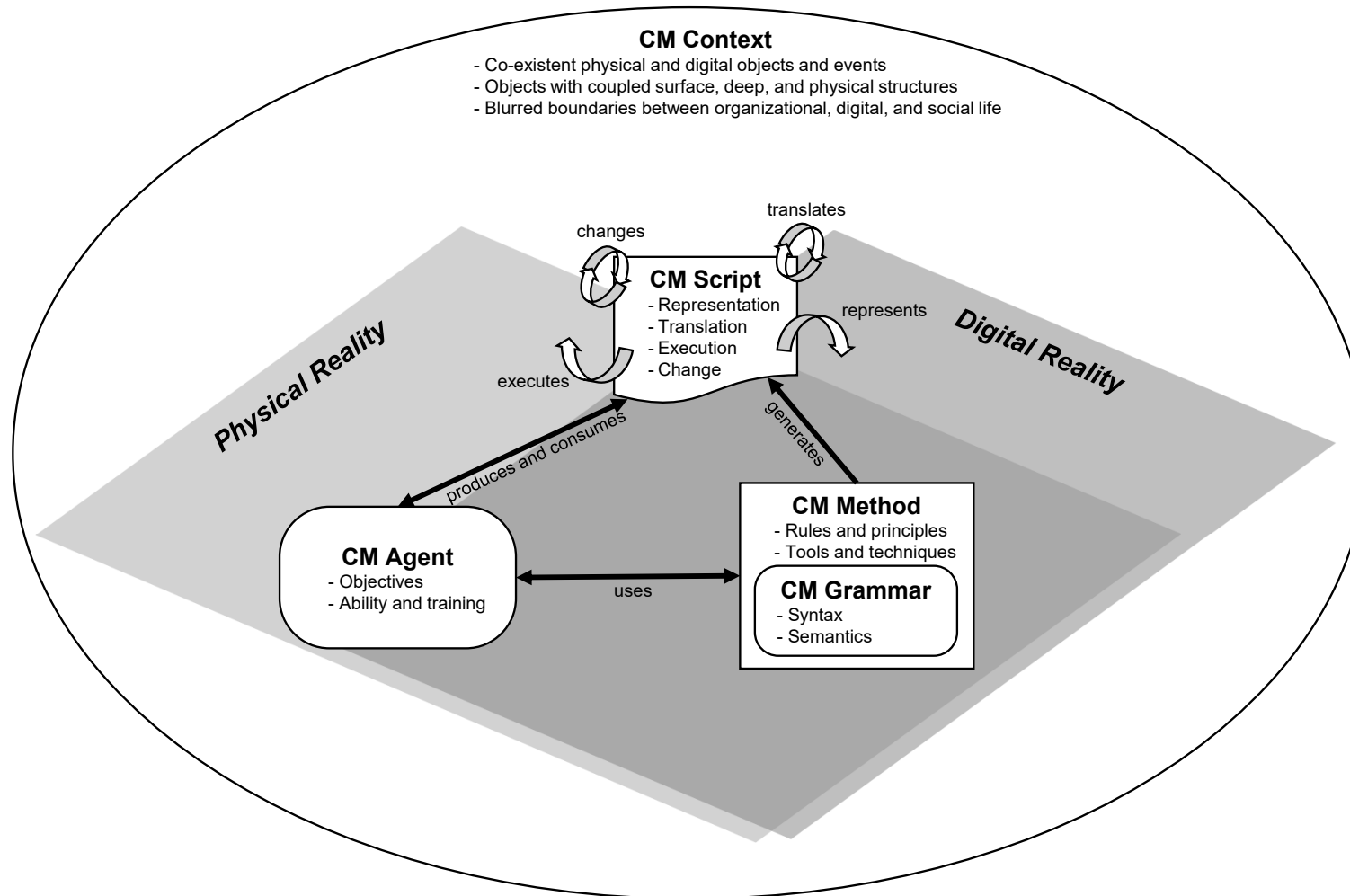
Wand, Y., & Weber, R. (2002). Research Commentary: Information Systems and Conceptual Modeling - A Research Agenda. *Information Systems Research*, 13(4), 363-376.



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# Relaxing our assumptions about conceptual modeling.

Type of assumption	Traditional assumption	Challenge to assumption
The representation assumption	Scripts represent physical reality.	Human experience is increasingly at least partially computed.  IS increasingly not only represents but also creates, shapes, and governs physical reality.
The structure assumption	Scripts represent the deep structure of IS.	Human experience increasingly involves digital objects, which blur the distinctions between physical, deep, and surface structures of IS.
The agency assumption	Scripts are produced and consumed by humans.	Digital objects increasingly have material agency.
The context assumption	CM is a professional activity that occurs in organizational work settings.	IS are increasingly developed and deployed not only in organizational work but also in the non-work settings of everyday life.



# New and updated key CM constructs

Construct	Wand and Weber's(2002) definition	Updated definition
<b>CM Script</b>	A statement generated in the language of a CM grammar that provides a description of the real-world phenomena that an IS is intended to represent.	<b>A generated statement that is suitable for purposes of mediation and provides a description of the phenomena of a physical and/or digital reality.</b>
<b>CM Method</b>	The procedures by which a CM grammar can be used.	Same
<b>CM Grammar</b>	A set of constructs and rules that shows how to combine the constructs to model real-world domains.	<b>A set of constructs and rules that shows how to combine the constructs to model physical or digital domains of reality.</b>
<b>CM Agent</b>	Not explicitly defined. Implicitly assumed to be a human agent that produces and/or consumes CM scripts	<b>A human or digital agent that produces and/or consumes CM scripts.</b>
<b>CM Context</b>	The setting in which CM occurs and scripts are used, including individual difference, task, and social agenda factors.	<b>The intertwined physical and digital reality setting in which CM occurs and scripts are produced and consumed.</b>
<b>Physical Reality</b>	The aggregation of constituent material and socially constructed things and their properties that exist in the real world.	Same
<b>Digital Reality</b>	-	<b>The aggregation of logical and non-material things and their properties that exist in the computed, digital realm.</b>
<b>Mediation</b>	-	<b>Activities related to facilitating representation, translation, execution, and change between aspects of physical and digital realities.</b>



**Thinking about  
conceptual modeling in  
this new way triggers  
four key changes.**

# Four key changes in thinking about CM:

1. The **CM script** is the focal CM artifact, not the grammar.
  - Scripts can be **ungrammatical** (do not have a meta model)

# Modern CM scripts are different.

<https://www.nytimes.com/interactive/2019/01/26/us/politics/trump-contacts-russians-wikileaks.html>

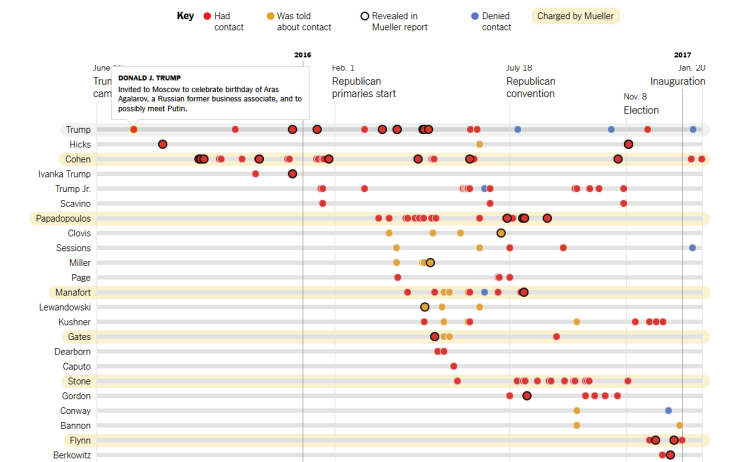
## Mueller Report Shows Depth of Connections Between Trump Campaign and Russians

By KAREN YOURISH and LARRY BUCHANAN UPDATED APRIL 19, 2019

Donald J. Trump and 18 of his associates had at least 140 contacts with Russian nationals and WikiLeaks, or their intermediaries, during the 2016 campaign and presidential transition, according to a New York Times analysis.

The report of Robert S. Mueller III, released to the public on Thursday, revealed at least 30 more contacts beyond those previously known. However, the special counsel said, "the evidence was not sufficient to support criminal charges."

Very few, if any, of these interactions were publicly known before Mr. Trump took office.



<https://www.technologyreview.com/2019/10/17/75285/ai-fairer-than-judge-criminal-risk-assessment-algorithm/>



Artificial intelligence / Machine learning

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The US criminal legal system uses predictive algorithms to try to make the judicial process less biased. But there's a deeper problem.

by Karen Hao and Jonathan Stray

October 17, 2019

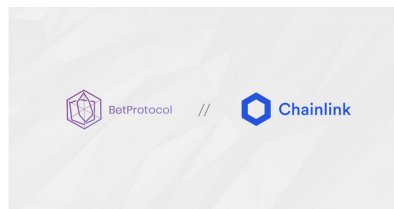
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# Four key changes in thinking about CM:

1. The **CM script** is the focal CM artifact, not the grammar.
  - Scripts can be **ungrammatical** (do not have a meta model)
2. The CM script do more than represent a reality.
  - **Representation** remains important but CM scripts also **change reality, translate between realities, execute within a reality.**

# Example: CM scripts can translate and effect change



BetProtocol Integrates With Chainlink for Esports and Sports Betting

## BetProtocol Partners With Chainlink for Esports and Sports Betting

BetProtocol Jan 21, 2020 · 2 min read



BetProtocol is connecting with Chainlink oracles as an option to provide decentralized Esports and Sports data to our operators.

Please visit our [Telegram](#) to join the discussion!

The integration allows BetProtocol to leverage Chainlink technology to develop oracles for gaming platforms. These oracles enable operators to use off-chain data (data that exists outside the blockchain) to reliably settle bets.



<https://betprotocol.medium.com/betprotocol-connects-with-chainlink-for-esports-and-sports-betting-129e02b9f853>



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  - Human agents do not have to be **professionals**.
  - We know **digital agents** exist but we have not yet conceptualized them.

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4. The CM context is situated in intertwined physical and digital realities.
  - We need to study **digital contexts** and also intertwined contexts (e.g., augmented reality)



# Three main implications for CM research:

1. A renewed focus on **CM design research**. This was the original focus but since the 90's the focus shifted to evaluation.
2. We need to research **new dependent variables** beyond comprehension and domain understanding.
3. Opportunities exist for **more collaborations** between CM scholarship and other research communities.



# Conclusion

- The role of CM for analysis, specification, and development of information systems has not **disappeared** – it has **changed**.
- **Modeling real-world domains** (be they physical or digital or both) **will remain key** to building better systems, better robots, better platforms, and apps.
- But **how** we do research on CM needs to keep up with the times. We need to be bolder and ask more questions where we might fail.
- Only by exploring **the territory of the unknown** can we push the usefulness of CM research further.



**Prof. Dr. Jan Recker, PhD**

**Chaired Professor for Information Systems and Digital Innovation**

Hamburg Business School  
University of Hamburg

email [jan.christof.recker@uni-hamburg.de](mailto:jan.christof.recker@uni-hamburg.de)

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