ENTERPRISE ARCHITECTURE FOR THE DIGITAL FUTURE

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• Internship and work at Enterprise Architecture (EA) vendor (BOC) 2007-2011
• Worked with EA data in my dissertation and published several papers on EA
• Program committee member for Trends in EA workshop 2015-2019
• Ties to multiple EA vendors/consultants including Scape, BOC, iteratec,...
• Cooperate with multiple companies regarding EA issues

• Main duties
  • Assistant Professor Digital Transformation and IT Infrastructures
  • Member of AIS, GI, Academy of Management OCIS
  • Main research area: IT management, besides that also interest in digital health
AGENDA

• Get a primer on EA from my personal perspective
• Learn about tool support for EA
• Theoretical underpinnings
• Hear about current IT trends and how they affect EA
• Is EA obsolete? What is the role of EA in the future?
ENTERPRISE ARCHITECTURE: MAIN ISSUES

- Complexity management / interdependencies
- Vendor and technology path dependencies
- Business versus IT viewpoints (and their alignment)
- Dynamic evolution (emergence versus planning)
Enterprise architecture (EA) is the name given to a set of conceptual frameworks, processes, and tools used to manage an enterprise’s information system architecture

-- MacCormack et al. 2015
MAIN PILLARS OF (TRADITIONAL) EA APPROACH

• **Level thinking**: business -- application -- information -- technology architecture
• **As-is / to-be planning**, architectural blueprints > strategic and tactical planning
• **Different viewpoints** (of the business/application/information/technology architect,...) frame concerns of stakeholders
• **Dependency analysis** to get an overview over different levels and their dependencies
• **TOGAF** as an overarching methodological framework (Architecture development cycle, metamodel,...)
• **EA as a institution / management function** > role of the enterprise architect and the architecture function in a company, **use of EA tools** to support the work of the enterprise architect
A SIMPLE METAMODEL FOR ENTERPRISE ARCHITECTURE

Source: Eckert, Fürstenau, Kirchner 2011 HMD Praxis der Wirtschaftsinformatik
TOGAF ARCHITECTURE DEVELOPMENT CYCLE

Source: TOGAF / The Open Group
STATE-OF-THE-ART EA TOOLS
THE CHOICE OF AN EA TOOL

• Homegrown IT repositories
  • advantage homegrown: fit to enterprise, customized
  • disadvantages: limited features, informed only little by standard frameworks, error-prone

• Dedicated EA tools
  • advantages: native support for EA framework, feature-rich
  • disadvantages: complex, inflexible, native cloud tools only emerging, not data science tools
GARTNER MAGIC QUADRANT ENTERPRISE ARCHITECTURE
MAIN PHILOSOPHIES OF EA TOOLS

• Database/repository approach
  • Structured database at the core
  • Visualization as an add-on to the database
  • Strong querying capabilities
  • Example: planning IT

• Modeling approach
  • Graphical modeling at the core
  • Repository emerges as a result of modeling
  • Visually appealing
  • Example: BOC ADOit
RELATION OF METAMODEL - REPOSITORY - VIEW/MODEL

Metamodel

(Object)Repository

View
DEEP DIVE BOC ADOIT: DEPENDENCY ANALYSIS

Source: Fill et al. 2016 Developing Cloud-based Enterprise Architectures Using Archetypes
DEEP DIVE BOC ADOIT: CAPABILITY MAP

Source: Kirchner 2011 Metamodell- und sichtenbasierte Ansätze zum werkzeuggestützten Management der Unternehmensarchitektur
Source: BOC - How to Demonstrate the Value of Business Architecture through Quick Wins
Source: CIO.de - 18 EAM Tools im Vergleich. https://www.cio.de/g/18-enterprise-architecture-tools-im-vergleich,105575,7
Source: Kirchner 2011 Metamodell- und sichtenbasierte Ansätze zum werkzeuggestützten Management der Unternehmensarchitektur
Source: CIO.de - 18 EAM Tools im Vergleich. [https://www.cio.de/g/18-enterprise-architecture-tools-im-vergleich,105575,7]
SUMMARY AND PITFALLS OF TRADITIONAL EA APPROACH

• Planning-centric view
• Tool-centric view: multiple consultancies now claim “lean approaches“ to avoid overreliance in tool support
• Degree of automation still limited
  • Effort for analysis and data collection > what is the method?
  • Limited comparability across enterprises on key measures
  • Where’s the (artificial) intelligence, optimization, learning?
THEORETICAL UNDERPINNINGS
• Network analysis and control theory (of complex systems) as the main theoretical underpinnings of EA

LOOK AT DEPENDENCIES, CENTRALITIES AND CLUSTERS

- A **network representation** displays the elements of an IT architecture and its dependencies.
- It allows the **identification of critical systems** through degree, betweenness, and Eigenvector analysis.
- It also allows identifying the **clustering/modularity structure** as an indicator of **separation tendencies**.

Source: Fürstenau and Rothe 2014, Fürstenau et al. 2019
MACCORMACK ET AL.’S WORK: LOOK AT INDIRECT AND CIRCULAR DEPENDENCIES OVER MULTIPLE LEVELS

- **Design structure matrices** are simple representations of an EA as a square matrix
- Used in system engineering and construction as a methodological tool to perform system analysis
- MacCormack et al. show that **number of indirect dependencies** of an element in the DSM is related to **costs of IT change**

Source: MacCormack et al. 2015 Building the Agile Enterprise: IT Architecture, Modularity and the Cost of IT Change
FUTURE WORK: TEMPORAL EVOLUTION OF EAS

• Use of network evolution algorithms such as (dynamic) **ERGM** (Exponential Random Graph Models) or SAOM to explain the evolution of EAs

• Use of simulation to understand structural pattern evolution, dependency on external perturbations, and influence of internal decision-making: **control points**

Source: Dreyfus et al. 2008, Fürstenau and Kliewer 2015, Haki et al. 2020
5 IT TRENDS AND HOW THEY AFFECT EA
1. AGILE ENTERPRISE

• **Agility** is defined as the ability to detect and seize market opportunities with speed and surprise (Sambamurthy et al. 2003)

• **Rapid scaling** of digital ventures enabled by unprecedented modularity and recombination possibilities of digital technologies (Huang et al. 2017)

• Introduction of new organizational **development methods** to support agility: agile (Scrum), Kanban, continuous integration, DevOps,... (Kraus and Wolter 2016, Wiedemann et al. 2019)

• Implications for Enterprise Architecture:
  • Challenge of **stakeholder involvement, getting relevant data, information provision** (Hauder et al. 2014)
  • Less focus on (long-term) planning, but more piecemeal, **iterative approach**
  • Less focus on “policing,” stronger focus on enabling **digital innovation**

Source: Fürstenau et al. 2019
Growth, Complexity, and Generativity of Digital Platforms
2. IT AND OT - OPERATIONAL TECHNOLOGIES

- **Internet of things (IoT)** is an enormous network of connected devices: sensors, controllers, actuators

- Based thereupon, **operational technologies (OT)** are defined as all the elements that support the daily operations of a company (Lara et al. 2019)

- Through IoT-based OT currently huge shifts are ongoing in many domains such as energy, production, smart buildings, facility management, etc.

- This leads to new architectural dependencies and associated **security vulnerabilities**

- Implications for Enterprise Architecture:
  - Need to integrate IT and OT
  - Need for domain-specific modeling methodologies

Source: Lara et al. 2019 OT Modeling: The Enterprise Behind IT

Source: [www.intel.com](http://www.intel.com) (Smarter Buildings Case Study)
3. ENTERPRISE ARCHITECTURE AND IT SECURITY

- Dealing with **security vulnerabilities** is becoming an increasing challenge for companies (Fenz et al. 2014, Ani and Tiwari 2017)
- Increasing awareness of people on **data security** and **privacy** issues, GDPR and other legislations.
- Security analyses increasingly demand that the **effects of attacks** from the infrastructure on the information and processes be made transparent
- Availability of open vulnerability databases such as Common Vulnerability Scoring System (**CVSS**)

**Implications for Enterprise Architecture:**
- Integrate separate streams of research (IT security and IT architecture)
- Need to develop methodologies that help in real-time risk assessment employing (extended) DSMs
- Develop heat maps and dashboards for decision-support

4. DATA-DRIVEN ENTERPRISE ARCHITECTURE AND ECOSYSTEM ANALYSIS

- Trend for companies to compete in larger networks, restructuring of value chains to open platform models and ecosystems
- Availability of open data on these ecosystems and tech stacks, e.g. Crunchbase, StackShare, Built With

- Implications for Enterprise Architecture:
  - Focus on boundaries of a single enterprise will be increasingly insufficient
  - Need to develop new tools for data-driven analysis of business and technology ecosystems

5. EA AND ARTIFICIAL INTELLIGENCE

- **Machine learning (ML)** enables to detect patterns in data through supervised, unsupervised and reinforcement learning methods.

- Complements traditional **search, optimization, and reasoning** methods from computer science and OR

- Commodityization of machine learning (ML) toolsets in combination with availability of more data drive down the **costs of prediction** in nearly every business area

- Implications for Enterprise Architecture:
  - Enhance/augment EA’s analytical capabilities through ML (e.g. Lufthansa: for redundancy detection)
  - Use more and more varied data sources to support EA decision-making
  - Reconfiguration of the EA process and changing role of the enterprise architect, need competencies needed

Source: Breithaupt and Kern 2019 ML Conference, Berente et al. 2019 MISQ Special Issue Call
TRADITIONAL EA APPROACH NEEDS TO TRANSFORM

• More automation
• More business- & information-centric
• More analytical
• More interdisciplinary
• More collaborative
• I personally don’t believe that leaner is necessarily better (Ashby’s law of requisite variety (1957): a complex environment can’t be dealt with by a simple approach)
• Overview of EA approach from my personal perspective
• Main approaches and capabilities of EA tools
• Network and control-theoretical underpinnings of EA
• Recent IT trends and how they affect EA
• Is EA obsolete?
  • EA needs to transform to stay relevant
  • Need to further develop the theoretical underpinnings of EA
  • EA needs more automation, more business-/information-centeredness, more analytical methods, interdisciplinary, collaborative, but not simpler
  • Maybe its called different then... Some proposals include....
    architectural thinking (Winter 2014), designed for digital (Ross et al. 2019) or simply

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