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Digital Transformation and Software/Requirements Engineering

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Digital Transformation and Software/Requirements Engineering

Carlos Henrique C. Duarte

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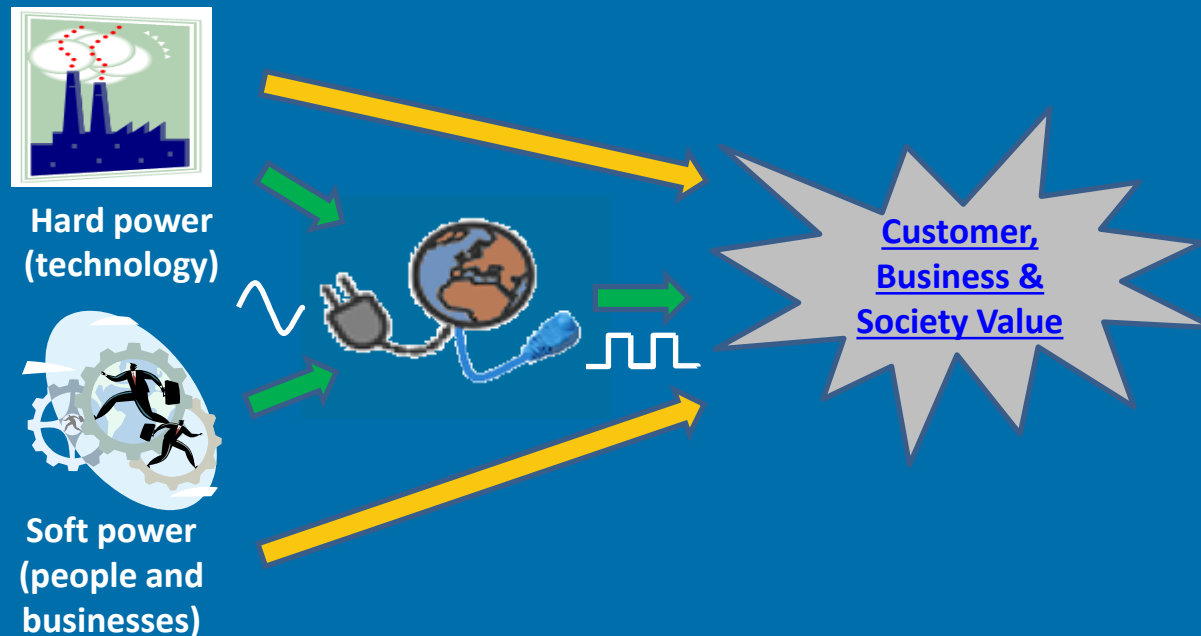
Support:



Talk Overview

1. What is Digital Transformation (DX)?
2. Why DX?
3. DX Who and Where?
4. How DX?
5. DX and Software/Requirements Engineering
6. Summary and Take-Aways

1. What is Digital Transformation?



- Digital Transformation (DX) is the adoption of (usually disruptive) digital technologies to increase value perception, productivity and welfare;
- DX results from the orchestrated and convergent usage of technologies in order to maximize value addition for persons, businesses and society;

1. The Trends Behind DX

Technology Perspective:

1. From analog to digital processing;
2. From discrete to continuous processes;
3. From process centric to customer centric focus;







Personal/Business Perspective:

1. From individual task-based to strategic thinking;
2. From individual competencies to holistic and integrated views;
3. From ownership-based to access-based businesses models;
4. From isolated to integrated collaborative business ecosystems;



1. The DX Opportunity: Access-Based Businesses

Company Name	Market Segment	Company Foundation	Digital Market Share	Total Market Share	Market Size Estimation Year	Studied Market Coverage	Market Data Source	Main Digital Competitor
	Retail	1993	49,0%	5,0%	2018	USA	bigcommerce.com	Ebay
	Hospitality	2008	19,0%	5,0%	2018	USA	vox.com / hotel-online.com	HomeAway
	Transportation	2009	67,0%	0,1%	2018	USA	vox.com / uber.com	Lyft
	Banking	2013	54,0%	2,6%	2018	Brazil	febraban.org.br	Banco Inter

1. The DX Business Opportunity

- The organization of persons and business in digital networks is a main source of emerging added value;
 - Due to the collaborative and combinatorial effects propelled by digital technologies;
- Digitization introduces opportunities to amplify and maximize value generation;
 - Due to the complete migration of persons and businesses to digital environments, with the additional interactions thereof;

The World Economic Forum (WEF) estimates the market size for DX in US\$100 trillion (2017). Just half of the existing companies have initiated their DX efforts.

McKinsey predicts that, by 2030, 14% of the global workforce – 375 million workers – may have to find new occupations due to DX efforts.

1. The DX Societal Opportunity

National governments, multilateral organizations and industry associations have produced strategic foresight studies to ground their long-term policies:

Perspective	Objective
Social	Foster the development of a more innovative and collaborative culture in industry and society
	Change the education system to provide new skills and future orientation to persons so that they can achieve excellence in digital work and society
	Create and maintain digital communication infra-structures and ensure their governance, accessibility, quality of service and affordability
	Strengthen digital data protection, transparency, autonomy and trust
	Improve the accessibility and quality of digital services offered to the population
Economic	Implement new and innovative business models
	Increase income generation, productivity and value addition in economy
	Improve the regulatory framework and technical standards

➤ Getting the right mix of smart investment, skilled workforce, innovation capability and effective governance is not straightforward!

Recent DX public policy examples:

1. German Digital Strategy 2025 (2010);
2. Digital China Agenda (2014);
3. Brazilian Digital Transformation Strategy (2018);

1. Digital Transformation Prospects

For companies:

1. Process improvement:
 - a. New markets exploitation;
 - b. Better value-chain integration;
 - c. Adaptability assurance;
2. Full digitization, through:
 - a. Complete redesign of products and services;
 - b. Adoption of holistic business models;
 - c. Establishment of closer interactions with suppliers;
 - d. Long-term partnerships with customers.

For customers/citizens/governments:

1. Better accessibility and quality of digital services and technologies;
2. Improved collaboration and innovation using digital tools;
3. Customer/citizen empowerment through monitoring and evaluation.

1. Digital Transformation Barriers

Internal (weaknesses):

1. Lack of DX strategy, focus and/or ROI visibility;
2. Inadequate or overly heterogeneous company structure or culture;
3. Low adoption and high ownership costs of digital technologies;
4. Weak digital governance, privacy and security protection;
5. Perception of cannibalization of existing businesses (innovators dilemma);

External (threats):

1. Shortage of skills and qualified labor force;
2. Lacking or insufficient public infrastructure;
3. Missing or inadequate regulation and customer protection;
4. Poor access to funding, particularly by small and medium size businesses;
5. Lack of value recognition in societal gains (welfare).

2. Why DX? Digital Transformation Rationale

- Technology has been a root cause of disruption (Christensen studies in 1995).
- Leading companies are constantly ahead of their industries in developing and commercializing new technologies, as long as these technologies address the next generation performance needs of customers.
- These companies are rarely in the forefront of commercializing new technologies that do not initially meet the needs of mainstream customers and appeal only to niche, small or emerging markets.
- Thus, disruptive companies explore the occupation gaps left by market leaders, by developing technologies for customers in niche, small or emerging markets.
- This is a source of innovation and market change, which Christensen illustrates by using price and performance data from the HDD industry.

2. Why/Where? Digital Transformation Rationale

- For Christensen, a differentiated package of performance attributes not yet valued by customers is what characterizes disruptive to be technologies.
- Performance attributes valued by existing customers evolve at such a rapid rate that new technology can eventually invade established markets.
- In order to assess whether some technology is of key importance for DX, one needs to ascertain its initial market, attribute package, disruptive character and strategic significance.
- Where? In mining and chemistry, agriculture and cattle breeding, food and beverage, automotive and electronics industries; services provided by governments and financial institutions; electricity, communications, gas and water utilities; healthcare and education institutions; retail, media and entertainment, logistics and transportation companies.

3. Case Study: DX at Telefonica

Organization: Telefonica Group (Spain and Brazil);

Scope: Vivo, the Brazilian subsidiary, developed Vivi, a social software robot to help customers formulate requests. The Telefonica group also deployed [Aura](#) in Brazil, a data integration platform with a cognitive assistant.

Techniques/Technologies:

1. Agile squads model: Autonomous independent development teams;
2. AI tools: Microsoft Azure with the [Bots Framework](#) (software robot IDE) and [LUIS](#) (a natural language understanding tool);
3. Open innovation: Wayra accelerator of startups;

Evaluation Metrics:

1. Vivi: 10 million sessions opened, 94% solved in automated way, in 2018;
2. Wayra: hosted 64 startups between 2012 and 2018;
3. Yearly cost reductions:
 - Courier: US\$156 million;
 - Call centers: US\$313 million;



3. Case Study: DX in Hospitals

Organizations: Samaritano and Sirio-Libanes Hospitals (São Paulo, Brazil);

Scope: 1. Secure electronic health records: management of patient data;

2. Integrated healthcare management systems: cover procedures, treatments, prevention, planning and decision;
3. Surgery robots: surgeries with high precision and freedom of movement;
4. Automated medicine distribution (just in Samaritano): selects, packs and distributes drugs throughout the hospital.

Techniques/Technologies:

1. Integrated healthcare management system: Tasy (Philips Healthcare);
2. Robotic surgical system: [Da Vinci Surgical System](#) (Intuitive Surgical);
3. Automated medicine distribution: [BoxPicker, PillPick and Pyxis](#) (Swisslog);

Evaluation Metrics:

1. Surgery robots: minimize patient risks and improve surgery precision;
2. Automated distribution: replaces 7 persons in dealing with 600 doses/hour.



3. Case Study: DX at Volkswagen

Organization: Volkswagen Group (worldwide);

Scope: 1. Connected embedded sensors/actuators for better control;

1. ICT workflows integrated from IT systems to each car;
2. Vertical integration with PLCM, ERP, PPC and ME systems;
3. Horizontal integration with 4/5G and RFID tags in vehicles and parts.

Techniques/Technologies:

1. Connected mechatronic systems: integrate mechanic and electronic systems (by Aptiv, Denso, Magna, Mahle and Schaeffler);
2. Electronic control units: ensure active vehicle control (by Bosch and ZF);
3. Infotainment systems: for passenger comfort (by Bosch and Continental);
4. 4/5G+RFID systems: vehicle/part communication/tracking (by [Kathrein](#));
5. Robotic systems: assemble complete vehicles from parts (by Kuka);

Evaluation Metrics:

1. Overall: 30% productivity gains in 3 years (2016) in Brazilian factories;
2. Products: All-electrical e-Delivery truck developed in Brazil for Ambev reducing gas emissions in 34%.

4. How to DX? The Outer Perspective

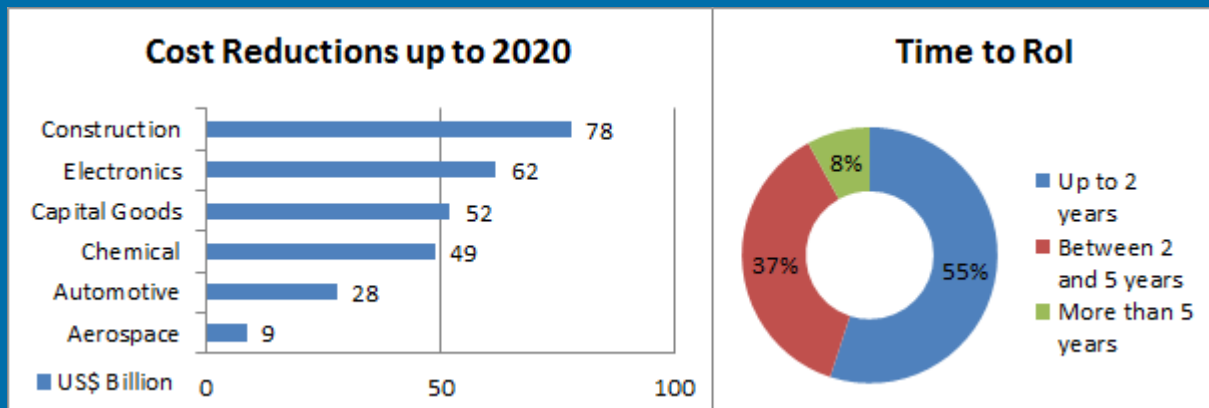
- The value chains that produce and deliver products/services do not matter anymore for customers, but continuous value generation matters through:
 1. Product customizations;
 2. Service simplifications;
 3. Unique customer experiences;
 4. New offerings.
- Cooperation with customers generates positive experiences, sentiments, convenience, comfort and well being, which are now all valued.
- Disintermediation of suppliers ensures faster product availability, better business integration and financial efficiency, defining an ecosystem economy.
- The competitive pressure generated by DX obliges customers and businesses to react to an ever-increasing digitization speed and adapt accordingly. Not all stakeholders are prepared to face this continuously changing environment.

4. How to DX? Strategies Before Technicalities

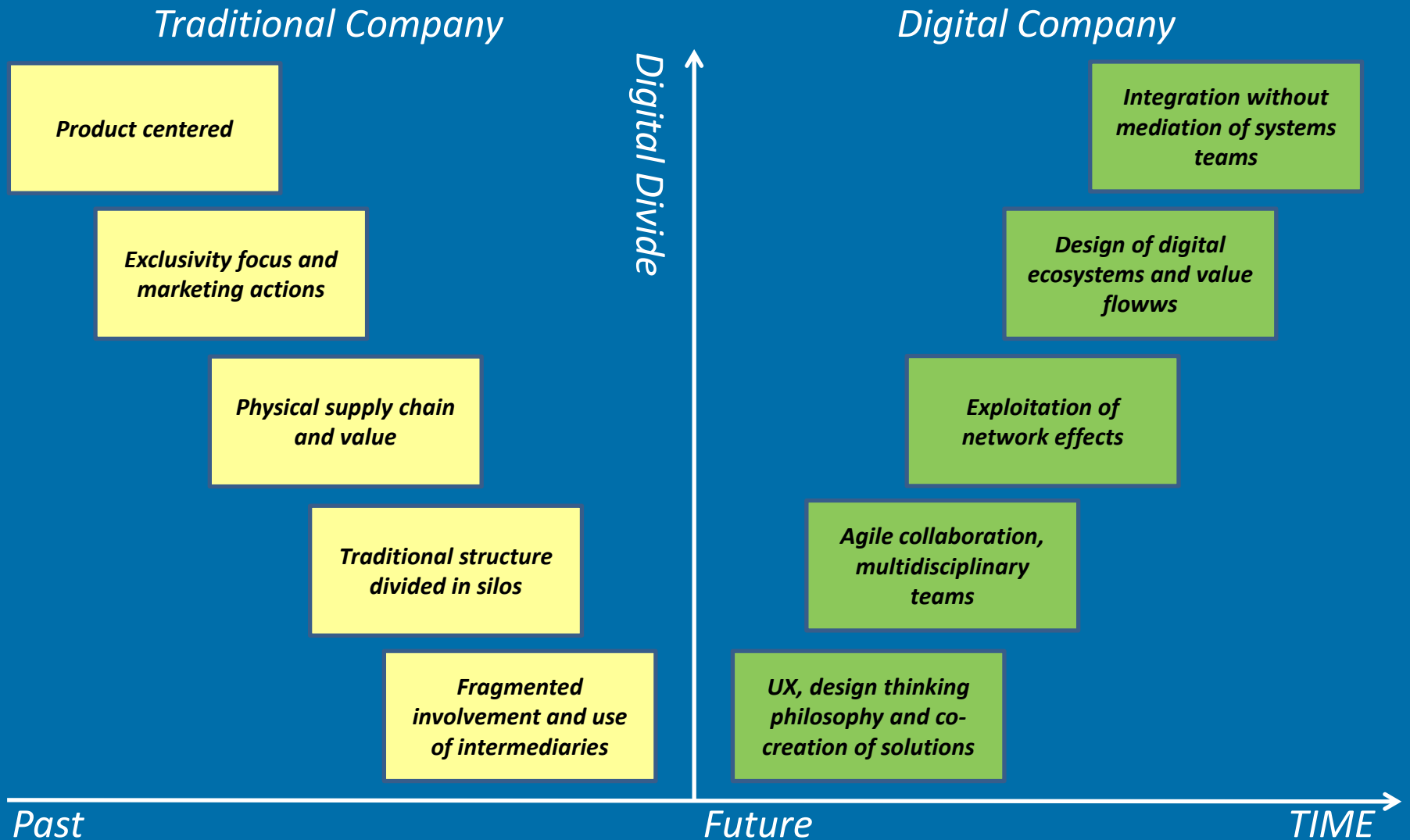
Companies have adopted standard strategic management practices to adapt to this new highly competitive environment, while better aligning business processes with adopted technologies:

1. Qualify: Make people awesome through creativity and entrepreneurship;
2. Simplify: Use best management, lean and sustainability practices;
3. Digitize: Use enabling technologies to generate value for customers;
4. Innovate: Find new ways to provide unique customer experiences;

Expected DX cost reductions and return on investment times by PwC (2017):



4. How to DX? Corporate Digital Transformation



4. How to DX? Strategies Before Technicalities

- Some companies have reorganized themselves to operate in dual mode:
 1. Standard mode: Keeps traditional businesses and operations running;
 2. Disruptive mode: Seeks additional opportunities to exploit new markets and to innovate in technologies, processes, products or services.
- Distinctive organizational patterns are adopted to support DX modes of operation (which are typical in technology transfer processes):
 1. Building in-house;
 2. Buying and partnering;
 3. Incubating or accelerating;
 4. Investing;

4. How to DX? Where versus How

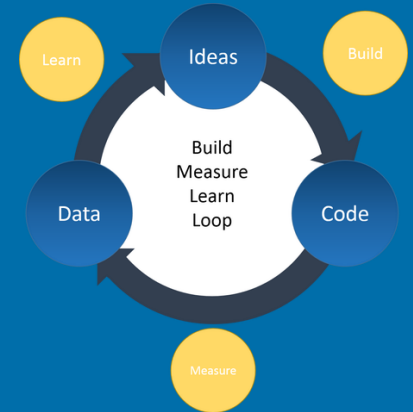
- A trade-off analysis is needed in deciding on Where versus How:



4. How to DX? Digital Transformation Methods

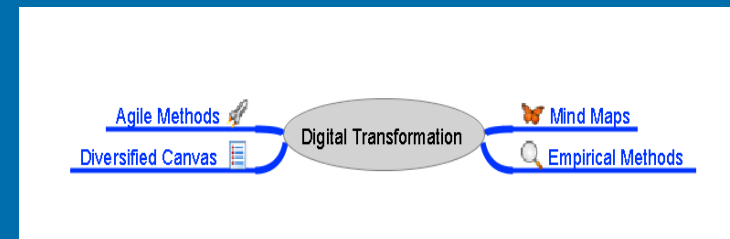
- It has become customary to adopt diverse approaches in digital transformation efforts:

1. Design thinking;
2. (Big) Data analysis;
3. Systems engineering;
4. Lean development;



- Some respective methods are:

1. Conceptual/mind maps;
2. Empirical methods;
3. Diversified canvases;
4. Agile methods;

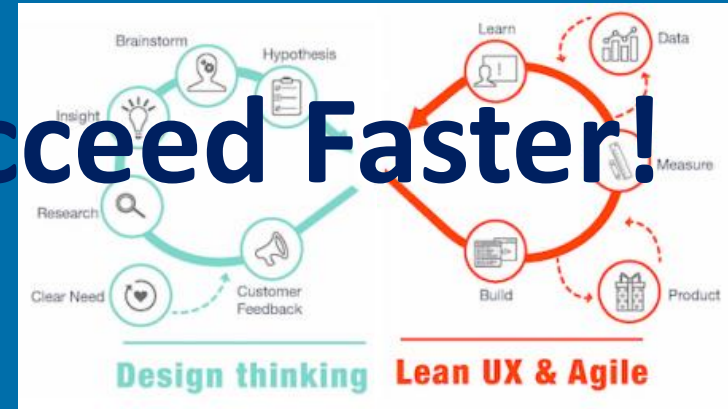


- The lean transformation model has been successful in promoting innovation through experimentation, independently of development location.

4. How to DX? Techniques Before Technologies



1. Value Proposition Canvas



Design thinking Lean UX & Agile



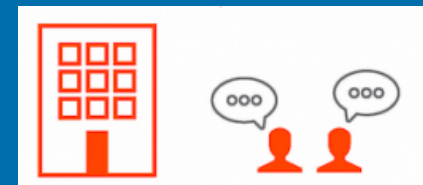
2. Brainstorm Assumptions
Write Hypotheses



3. Experiment Minimum Time
Design Success Metric Box



5. Results (Minimum Viable Product)
Insights & Learning
Decision (Pivot/Persevere)



4. Get out of the building
Talk to potential customers

4. How to DX? Technologies to Meet Demand

- The DX enabling technologies can be classified according to their span from the **visible and tangible** world to the **invisible and intangible** world.
- Examples of tangible technologies:
 1. Collaborative or autonomous equipment (robots and drones);
 2. 3D printers (eg. GE [ARCAM](#)).
- Examples of invisible technologies:
 1. Advanced sensors and actuators;
 2. Micro devices connected through the Internet of Things (IoT).
- Examples of intangible (software-based) technologies:
 1. Advanced/big data collection and analysis, with (cloud) storage;
 2. Convergent real-time interactivity and cognition;
 3. Augmented reality with visualization and simulation;
 4. Pattern recognition, machine learning and artificial intelligence.

4. How to DX? Technologies to Meet Demand

- Examples of underlying enabling methods, techniques and tools:
 1. Techniques/platforms for agile/lean software development: [IBM Bluemix](#);
 2. Blockchain/Hyperledger for ensuring security and trust: [Ethereum](#);
 3. Micro-services and open APIs for software architectures: [Google Apigee](#).
- Another classification is based on the nature of the technologies themselves: hardware, software and peopleware.

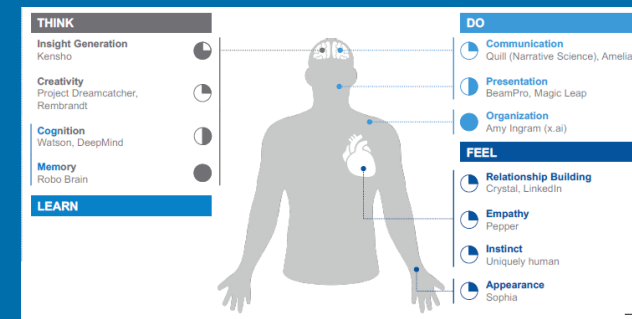


5. DX and Software/Requirements Engineering

- DX has not led to the development of radically new software technologies, but rather to new technology applications, due to the additional requirements that must be satisfied.
- Practical DX problems have become tractable by software only with effective development management, reusability and requirement engineering methods, techniques and tools.
- These Software Engineering branches with many interfaces, which deal with unproven metrics, have hard complexity bottlenecks and generate imprecise specifications respectively.
- Nowadays, approaches like DevOps using PaaS have ensured new revenues with higher productivity based on continuous software delivery processes.
- The human factor is central in addressing these issues, but the required key competences for problem solving, managing complexity and dealing with high levels of abstraction are often lacking or insufficient. Upskilling is a need.

5. SE/RE Skills and Capabilities for DX

- The OECD classifies the required skills of software developers in:
 1. Generic: Use of office software, Internet navigation and browsing etc;
 2. Specialist: Development of software, web-pages, cloud data and analytics;
 3. Foundational : Social and emotional skills, digital literacy and critical thinking;
 4. Complementary: Information processing, communicating with partners and customers, problem solving, planning in advance and adjusting quickly.
- The WEF classifies the required capabilities of software developers in:
 1. Thinking : insight generation, creativity, cognition and memory;
 2. Doing: communication, presentation and organization;
 3. Feeling: relationship and trust building, appearance, empathy and instinct;
 4. Learning: motivation and proactivity.

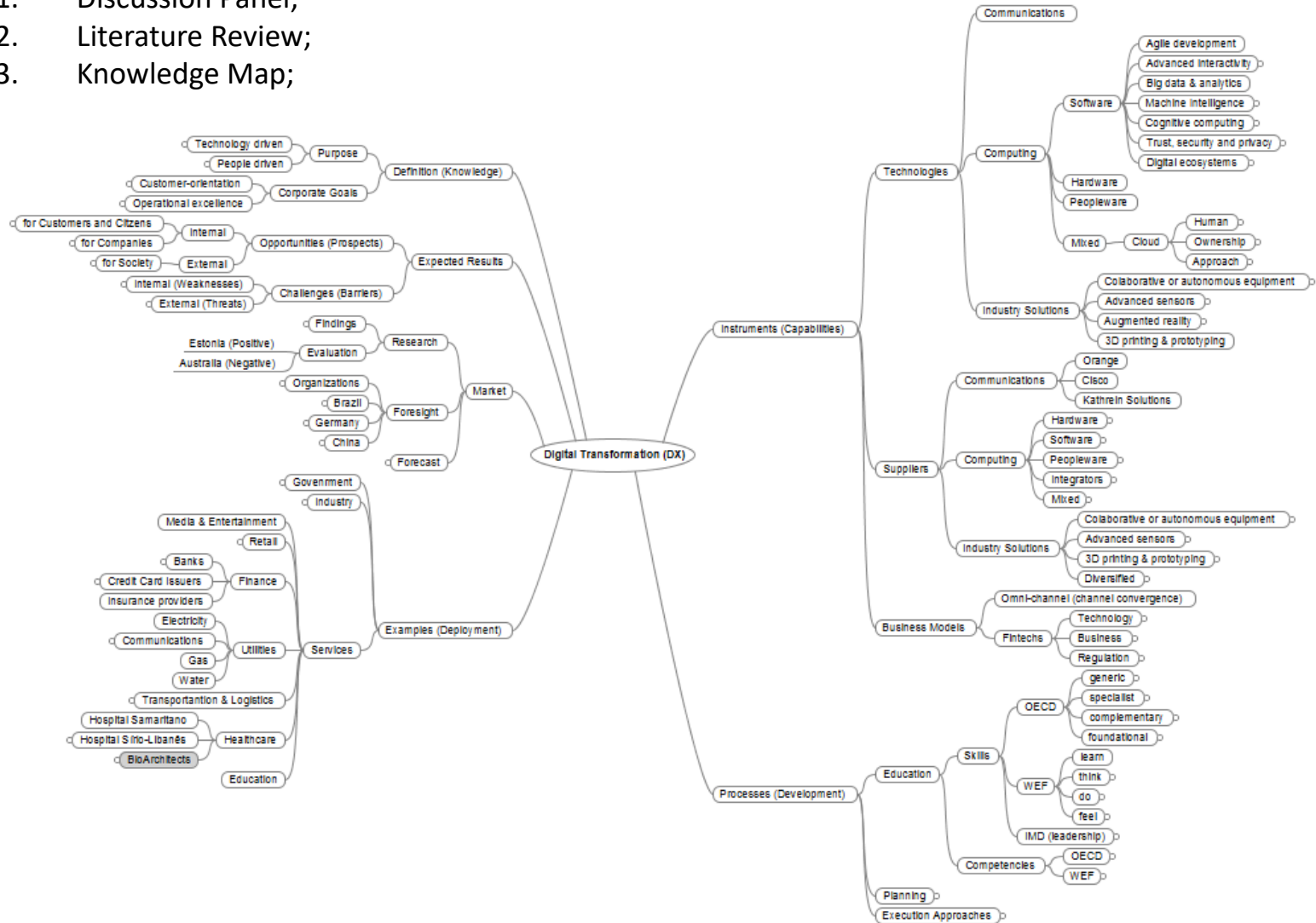


5. SE/RE Issues Due to DX

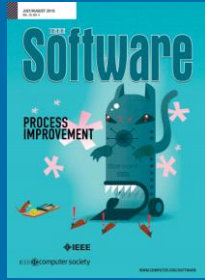
- Due to DX, at higher organizational levels:
 1. Managers are expected to change their mindsets and abandon command and control, moving to more participatory and leadership oriented, risk taking and mistake tolerance approaches;
 2. Corporate leaders need to stimulate, direct and support their autonomous teams, while inspiring and learning together with them;
 3. Executives must be prepared to face business environments where (hyper)awareness, informed decision-making and fast execution rule.
- DX challenges traditional SE/RE education: now we need to teach how to learn!
- Apart from classroom and learning-by-doing, we see increased interest in:
 1. Continuous learning programs;
 2. Gamification and simulation exercises;
 3. Massive open online courses (MOOCs).

How This Work Was Developed

1. Discussion Panel;
2. Literature Review;
3. Knowledge Map;



To Probe Further



1. Christof Ebert and Carlos Henrique C. Duarte. Digital Transformation. *IEEE Software* 35(4):16-21. July 2018.
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* The photos and videos in this presentation were obtained on the Internet.

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