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CDTM Center for Digital Technology and Management

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Executive Summary

Embodied intelligence: Driving the digital transformation 2.0

Digitalisation is a highly dynamic process. Through digital transformation, it leads to a completely new dimension of economic architecture. A useful definition of the term "digital transformation" is provided by Cheng Gong and Vincent Ribiere[1] and this has been expanded and taken further in the course of the present study. It essentially describes an extension of machines by means of embodied intelligence, which act alongside human beings as users of digital platforms. But what are machines with embodied intelligence,[2] and why do they play such an important role? The short definition is: systems that act autonomously and in future will react to their environment in an intelligent way. The role of embodied intelligence is to ensure that this happens in the optimal way. In this context, a series of dynamic interactions brings about an information flow between actuators, sensors and artificial intelligence, in which crucial limits are set for the embodiment in terms of both the sensor signals and the motor activities. Randomly generated movements thus gradually turn into targeted behaviour. These are systems that function with little, if any, human intervention.

Nowadays there are many so-called self-regulating systems around us, such as artificial earth satellites, aircraft without human pilots and navigation devices that set the route for drivers. Another good example is systems that maintain life, such as medical respirators and synthetic hearts. They can control a series of parameters, select the most suitable operating mode and identify critical situations. There are also programs that estimate the value of shares and other securities, react to price changes, buy and sell shares, carry out thousands of transactions a day and optimise profits. Today's self-regulating systems are technical and IT networks in the form of robots

[1] Gong, Cheng; Ribiere, Vincent: "Developing a unified definition of digital transformation", Technovation, Volume 102 (2021), 102217, ISSN 0166-4972, https://doi.org/10.1016/j.technovation.2020.102217

[2] Based on: Cangelosi, Angelo; Bongard, Josh; Fischer, Martin H.; Nolfi, Stefano: "Embodied Intelligence", in Janusz Kacprzyk & Witold Pedrycz (Eds.), Springer Handbook of Computational Intelligence. Springer, Preprint (2015),pp. 697–714, https://www.researchgate.net/publication/283812826_Embodied_Intelligence

or computer programs. Systems of this sort are working increasingly autonomously and handle ever more complex tasks, but most are not based on embodied intelligence. Machines with embodied intelligence are, by contrast, highly developed – in the sense of self-regulating and highly autonomous. You can already see the first examples of them now, but they will only appear on a mass scale in much more sophisticated forms in the future.

In the view of the authors of this study, this is the basic central innovation of the next Kondratieff cycle in the medium term.[3] An economic architecture is proposed which emerges from the difficult environment of transformation and is based around the purpose economy.

The combination of minimal transaction costs of the platform economy and low functional costs resulting from the increased use of machines with embodied intelligence leads to the optimal, holistic resource efficiency. This economic framework can help define a clear corporate purpose and develop new business models. It constitutes a good basis for an ecological and economic realignment. This fundamentally means that a large part of the current value creation of all markets will become obsolete, without any compromises in terms of functionality for the end customer. On the contrary: it will lead to an explosion of functions for the end customer, without requiring significantly more resources.

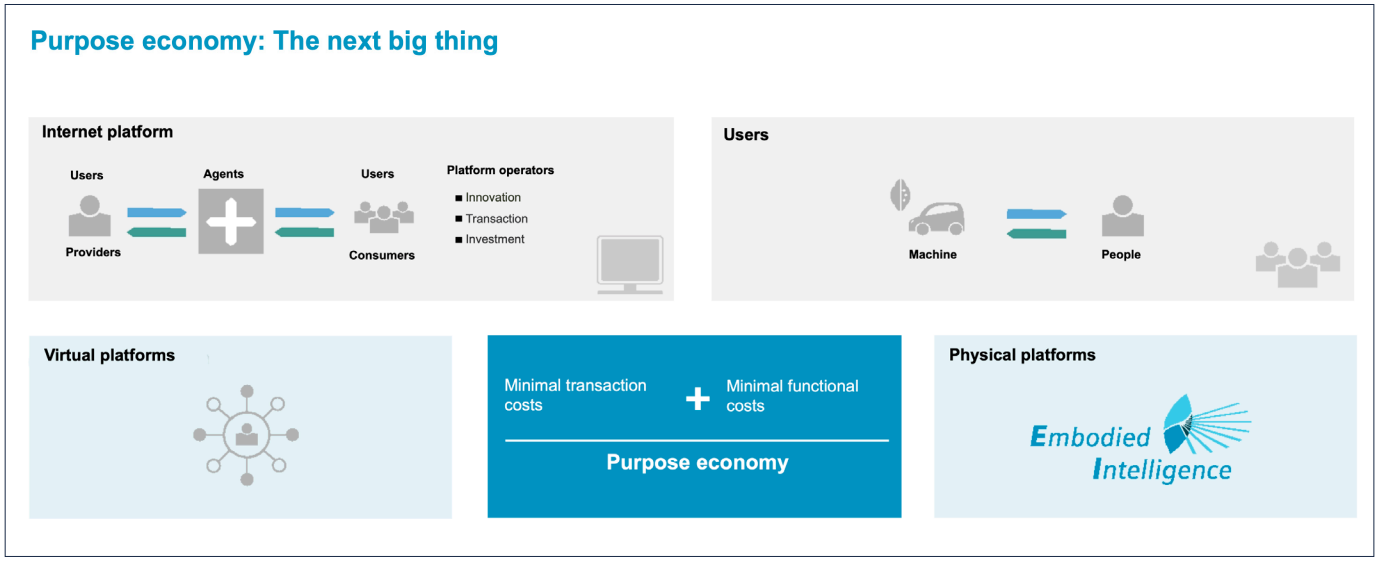

Figure 1: The platform economy and embodied intelligence are enablers for the purpose economy

The economic approach described here will lead to the development of new infrastructures. Communications and energy networks will experience the biggest changes in the medium term. The conversion of the global energy sector from fossil fuels to carbon-free energy supply by the second half of the 21st century will accelerate the development towards a new form of machines with embodied intelligence. In the case of the so-called energy transition, the need to reduce energy-related CO_2 emissions in order to limit climate change is the central point. Decarbonisation of the energy sector requires urgent measures at a global level. Although the global energy transition began over 20 years ago, other measures are necessary to reduce CO_2 emissions and mitigate the effects of climate change. The authors regard the combination of embodied intelligence with renewable energy and the use of the platform economy to boost energy efficiency as a central lever in achieving the necessary reduction in carbon emissions. Machines with embodied intelligence are the essential drivers for a significant reduction in the consumption of energy and resources.

[3]Bernard, Lucas et al.: "Time Scales and Mechanisms of Economic Cycles: A Review of Theories of Long Waves", Political Economy Research Institute, University of Massachusetts Amherst, Workingpaper Series No. 337 (December 2013), S. 2, https://peri.umass.edu/fileadmin/pdf/working_papers/working_papers_301-350/WP337.pdf

Platform economy is a term that characterises the economic approach of the most valuable companies in the world at the moment: instead of conventional products, they offer platform-based services. Platforms typically operate through a core transaction. It determines the way in which producers and consumers create and consume values. The core transaction consists of a series of actions which users carry out to exchange values via the platform; it forms the basis for every platform transaction. Ultimately, the core transaction on any platform consists of the processes of creating, connecting, consuming and compensating. Only with these actions can a platform process transactions successfully. Together they offer the user a repeatable way to exchange values. In the digital economy, this is evident on the internet, in particular in the form of strong network effects and in returns to scale. If the expected benefit of a product or service increases with a growing number of users, this is referred to as a direct network effect. Direct network effects of a positive sort come about, above all, on internet platforms.

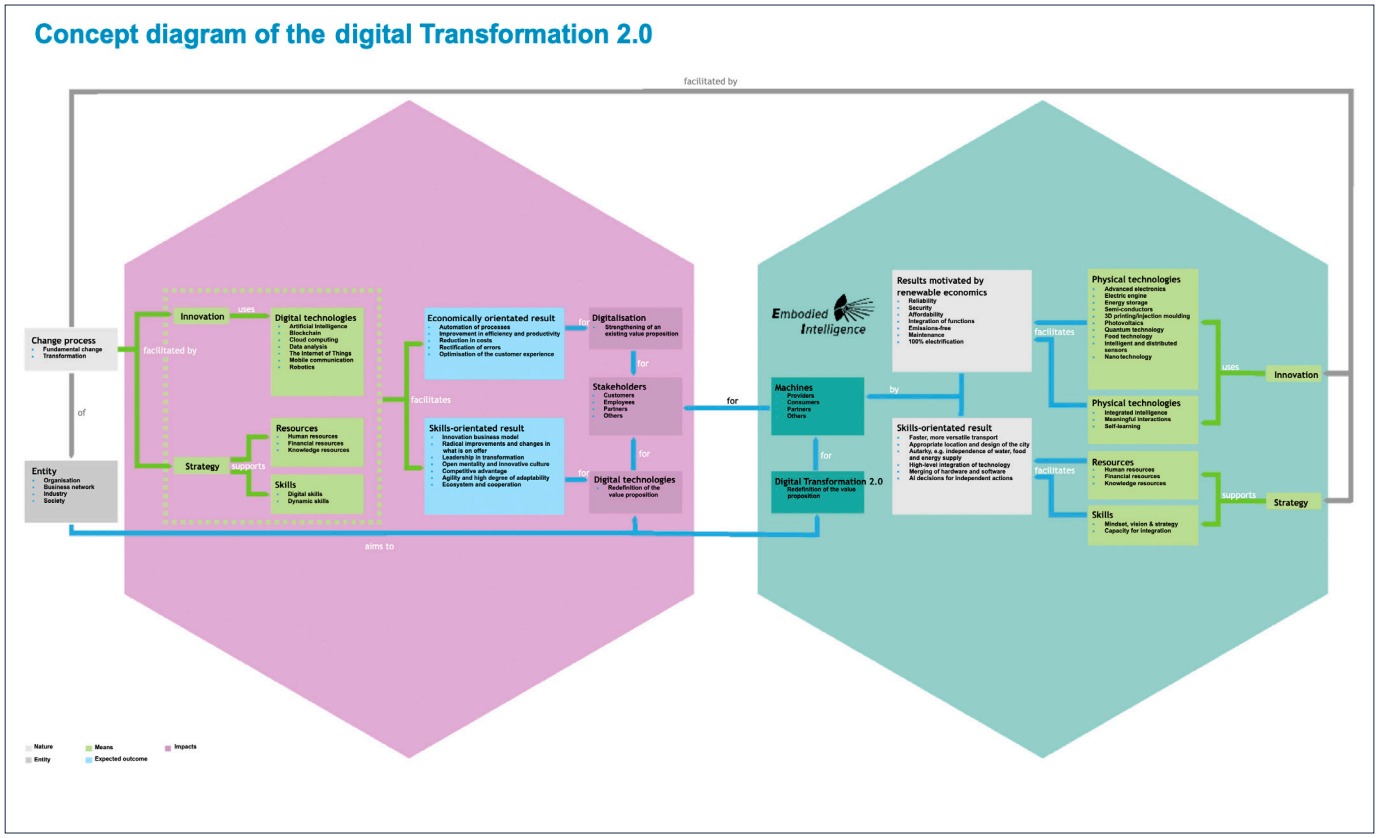

Figure 2: Concept diagram of the digital Transformation 2.0 with a sample of the necessary technologies, resources and skills [4]

Strict user orientation leads to an entirely new target system for the platform economy and differs fundamentally from traditional market forms. Put simply, the platform economy forms the economic basis for the digital transformation. Platforms have established themselves in almost every area of application (mobility, retail, production and healthcare, for example), with market leaders setting up their own platforms and networking with external platforms. In future, the digital transformation will set the economic standard by which all other transformational approaches will be guided. The rise of the platform economy in the sense of intelligent service platforms is putting established service concepts into question and changing them. In future, users will

[4]Gong, Cheng; Ribiere, Vincent: "Developing a unified definition of digital transformation", Technovation, Volume 102 (2021), 102217, ISSN 0166-4972, https://doi.org/10.1016/j.technovation.2020.102217

mainly be end consumers and machines with embodied intelligence that are able to offer services on a platform autonomously. The new types of machines build heavily on the principle of high-level integration and are thereby replacing the current dominant principle of networking. The authors are convinced that the spatial proximity of sensors and actuators in conjunction with artificial intelligence will provide a greater functional benefit. Communication still plays a very important role in this, although its form and basic requirements may differ significantly from current solutions. New physical approaches and their capacity to support high-level integration will become the drivers of technical changes in the coming years.