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Constructing an AI Value Chain and Ecosystem Model

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Constructing an AI Value Chain and Ecosystem Model

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Abstract

The aim of this paper is to construct a model of the AI value chain and its underpinning ecosystem. This model could then be used by countries and enterprises:

- to identify their current AI value chain activities,
- to analyse current value chain strengths and weaknesses, and
- to develop a strategy for maximising value-building including AI value chain upgrading.

A. Introduction

What national strategy should countries adopt in order to benefit most from the coming artificial intelligence (AI) tsunami? What organisational strategy should digital economy enterprises adopt in order to profit most from AI?

We are not going to answer those questions in this paper. Instead, we argue that foundational to answering those questions is a model of the AI value chain: the stages involved in creating value through development and deployment of AI technologies. The aim of this paper is to construct a model of the AI value chain and its underpinning ecosystem. That model could then be used by countries and enterprises:
- to identify their current AI value chain activities,
- to analyse current value chain strengths and weaknesses, and
- to develop a strategy for maximising value-building including value chain upgrading.

The model is constructed from a review of AI value chain literature. That literature offers several different models. Each of these has a different emphasis which collectively demonstrate that these current models cover only part of the picture. The purpose here is therefore to synthesise these partial models into a single comprehensive model, and then a more simplified version.

B. The Starting Point

We begin with two basic models. The first is sectoral and specifically tagged as the machine learning value chain (Stanton et al 2019; see Figure 1). It forms the central foundation for the ultimate AI value chain model and consists of five steps:

- "*Data collection* involves the gathering of raw data from any number of sources.
- *Data storage* involves amassing raw data in data centers.
- *Data preparation* involves efforts to clean, convert, format, and label raw data.
- *Algorithm training* involves configuring an algorithm to make predictions from data.
- *Application development* converts algorithmic predictions into commercially viable products."

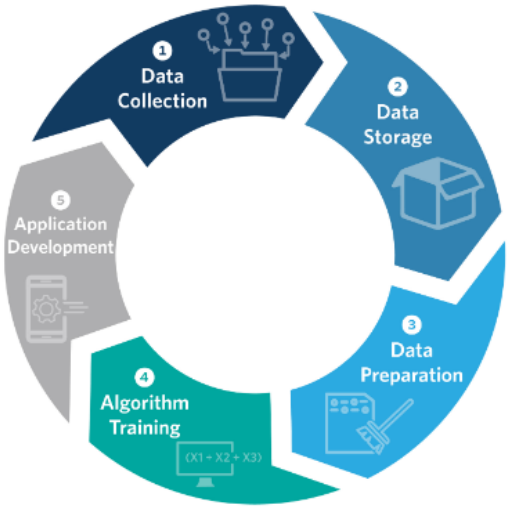

Figure 1: The Machine Learning Value Chain (Stanton et al 2019)

The second model is specific to development of an individual AI model (Engler & Renda 2022; see Figure 2). It collapses the three data stages of the first model into one stage and provides several stages in relation to the building of models. Its core contribution is the recognition that the building of models – especially general purpose / foundation AI models – rather than the training of algorithms is critical to the AI value chain. The specific value and its distribution will vary depending on whether the model developed is open-source (meaning the model or parts of it are publicly released) or proprietary (meaning the model is accessed only via an application programming interface) (Kuspert et al 2023).

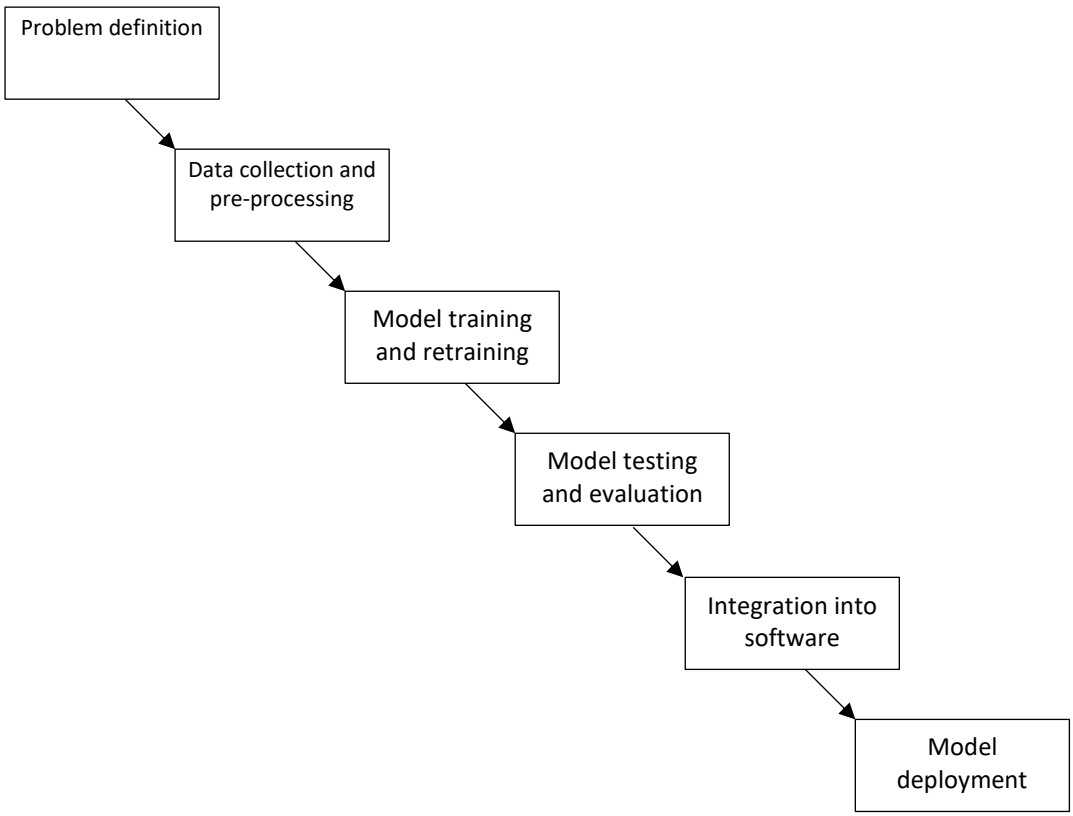

Figure 2: The Individual AI System Value Chain (developed from Engler & Renda 2022)

C. Expanding the Downstream AI Value Chain

The AI value chain so far just consists of "application development" as the downstream component. Staff at McKinsey, focussing specifically on generative AI, expand this into three elements: machine learning operations (MLOps), applications, and services (Harlin et al 2023). These are explained and also illustrated in Figures 3a and 3b.

Of the three, MLOps is the fuzziest. It has become something of a catch-all term to encompass all of the technologies associated with building AI applications, from the platforms or hubs that host AI app development to all of the "picks and shovels" tools for app development and management of app development including tools for data processing, testing, cyber-securing and maintaining the AI applications (Rao 2023, SPEAR Invest 2023). Applications are sometimes divided into horizontal AI that focuses on a generic task such as copy.ai or Jasper for writing text or GitHub Copilot for writing code (SPEAR Invest 2023), and vertical AI that serves particular industries such as the Tempus AI suite for healthcare or Taranis' AI-based precision agriculture applications. Services are the value-added activities based around human knowledge which might relate to: "a specific function (such as how to apply generative AI to customer service workflows), industry (for instance, guiding pharmaceutical companies on the use of generative AI for drug discovery), or capability (such as how to build effective feedback loops in different contexts)" (Harlin et al 2023).

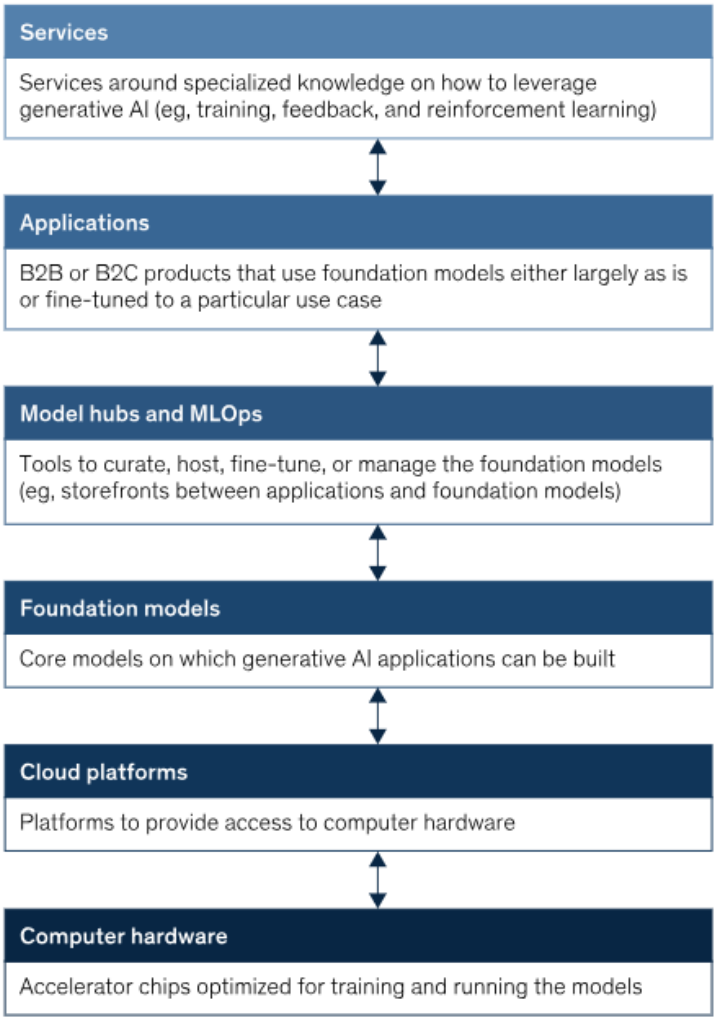

Figure 3a: The Generative AI Value Chain (Harlin et al 2023)

Figure 3b: Examples for the Generative AI Value Chain (Newman 2024)

Narrowing the focus to generative AI imposes an important limitation of potentially ignoring other types of AI such as applications in basic chatbots or in physical systems such as autonomous vehicles or robotics (though many aspects of the value chain would be similar). The counter-argument is the dominance of generative AI within the overall AI landscape (Gartner 2023, Tandon 2024).

D. The Wider AI Ecosystem

The McKinsey model doesn't just expand the downstream elements of the AI value chain; it also add two more elements: computer hardware and cloud platforms. These could be added on to the start of the AI value chain as upstream components but it seems more appropriate to identify these as part of the infrastructure for the core AI value chain – elements that form part of the wider AI ecosystem and which are necessary foundations for that AI value chain to operate.

While frequently called "cloud", the mediating layer between hardware and AI is more typically thought of as "compute infrastructure" – often instantiated in data centres – that itself is built on three elements (Shih 2021, Van Roy et al 2021, Rao 2023, SPEAR Invest 2023):

- Hardware in the form of integrated circuits: principally thought of in terms of graphics processing unit (GPU) and central processing unit (CPU) chips for data processing, but also memory chips for data storage, and the communication circuitry to link chips into massive arrays.
- Software: the software required to run the other infrastructure such as data centre management software, and more AI-specific elements such as code for machine learning algorithms.
- Other: this includes the telecommunications infrastructure that links data centres to AI developers and users, and the energy infrastructure necessary to power data centres

All of this infrastructure is empty unless populated by data. It is therefore appropriate to see the contextual data infrastructure as part of the AI ecosystem (Van Roy et al 2021, SPEAR Invest 2023). The data storage elements of this can already be seen as covered in the cloud-compute infrastructure of data centres, so this will refer more to the scale and availability of data e.g. in terms of open data, data markets, data exchanges, and other data sources and providers (Demchenko et al 2018). Given that AI services generate data, then while the chain will be portrayed mainly as linear rather than as cyclical as per Figure 1's model, some element of this feedback can be acknowledged.

These represent the technical elements of an AI ecosystem but there are also non-technical elements required for AI value chains to operate (Oxford Insights 2024). These include:

- AI-related institutional infrastructure such as national AI policies or organisational AI strategies and the associated bodies for their development and implementation,
- AI-related human infrastructure in terms of the trained personnel with necessary expertise to execute the stages of the core value chain, and
- AI-related financial infrastructure able to provide the – often long-term, large-scale – funding for AI.

E. The AI Value Chain and Ecosystem Model

Putting all of these elements together, produces the model shown in Figure 4. The top two layers form the AI ecosystem, and the bottom layer forms the AI value chain.

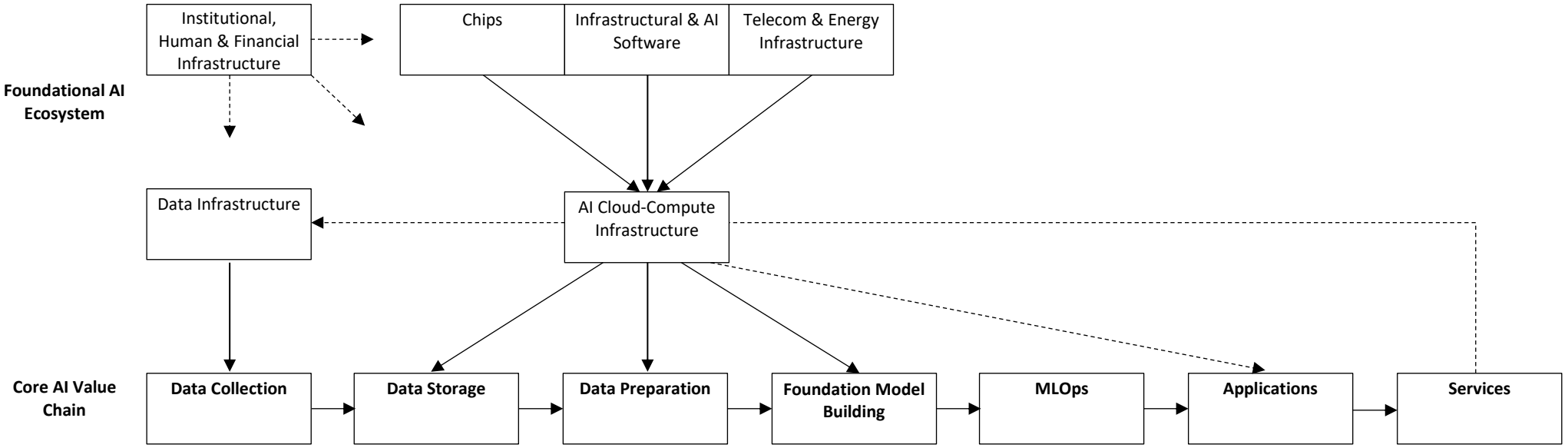

Figure 4: The AI Value Chain and Ecosystem Model

F. A Simplified AI Value Chain

The model in Figure 4 is comprehensive but it is also complex. It therefore makes sense to offer a simplified version. Reversion to the original model in Figure 1 would be perfectly feasible but instead it was decided to follow something more like the McKinsey model but with some limited revisions based on elements from other models. The result is shown in Figure 5. The components should be readily understood from the previous discussion, except to note that "informatics infrastructure" would cover data, hardware and software, including telecommunications infrastructure.

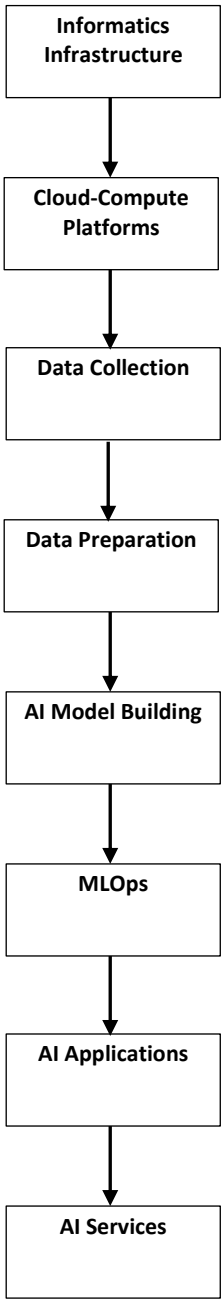

Figure 5: Simplified AI Value Chain

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