Rethink Agile Scaling with Robotics Subsumption Architecture

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1 Introduction

Agile has transformed the way organizations deliver value. At the team level, Agile often brings remarkable speed, autonomy, and innovation. However, many organizations face significant challenges when scaling Agile across multiple teams. Coordination overhead increases, decision-making slows down, and the autonomy that made small teams successful often erodes.

How can organizations grow while preserving the agility that made them thrive? How can we scale without losing speed, autonomy, and responsiveness?
In this paper, we explore an innovative approach inspired by robotics: the ***Subsumption Architecture***. Originally designed to create adaptive, autonomous robots, Subsumption offers powerful lessons for designing an organization's ecosystems. Building on the late ***Mike Beedle's*** pioneering work in applying these principles to organization design, we reimagine how to build organizations that are resilient, decentralized, and capable of dynamic, real-time adaptation—even as we grow.

2 Comparison with Established Agile Scaling Frameworks

While frameworks like SAFe, LeSS, and Scrum@Scale aim to bring order and coordination to scaling Agile, they often rely on structured, top-down mechanisms that can hinder adaptability and autonomy. In contrast, Robotics Subsumption Architecture provides a fundamentally different paradigm for scaling agile. The following comparison highlights key differences:

Aspect	Established Agile Scaling Frameworks	Robotics Subsumption Agile Scaling Approach
Hierarchy & Structure	Typically, top-down, with structured layers for alignment and governance.	Subsumption-based and emergent; higher layers decide when to use or override lower layers.
Decision-Making	Often centralized at higher levels (e.g., Program or Portfolio).	Decentralized; lower layers act autonomously unless overridden by higher layers.

Adaptability	Change is managed through scheduled planning cycles (e.g., PI Planning, Sprint Reviews).	Real-time adaptation, as lower layers adjust continuously based on signals they receive.
Coordination & Dependencies	Dependencies managed via structured synchronization (e.g., SAFe ART Sync, LeSS Overall Planning).	Dependencies self-resolve through adaptive behavior—*Surfers* (domain experts) move across teams to align work.

Rather than building hierarchy to manage complexity, subsumption-based ecosystems distribute sensing and action across layers, allowing the system to continuously adjust and evolve—much like autonomous robots navigating a dynamic environment.

3 Background

3.1 Robotics Subsumption Architecture

Developed by Prof. Rodney Brooks in the 1980s, **Subsumption Architecture** introduced a revolutionary **architecture** for building intelligent, adaptive systems. It was proposed in opposition to traditional **symbolic AI**, which attempted to guide behavior through internal models and symbolic mental representations of the world. It does this by decomposing the complete behavior into sub-behaviors. These sub-behaviors are organized into a hierarchy of layers. Each layer implements a particular level of behavioral competence, and higher levels are able to subsume lower levels (= integrate/combine lower levels to a more comprehensive whole) in order to create viable behavior. For example, a robot's lowest layer could be "Avoid Objects." The second layer would be "Wander Around," which runs beneath the third layer "Explore World." Because a robot must have the ability to "Avoid Objects" in order to "Wander Around" effectively, the Subsumption Architecture creates a system in which the higher layers utilize the lower-level competencies. The layers, which all receive sensor information, work in parallel and generate outputs. These outputs can be commands to actuators, or signals that suppress or inhibit other layers. [1]

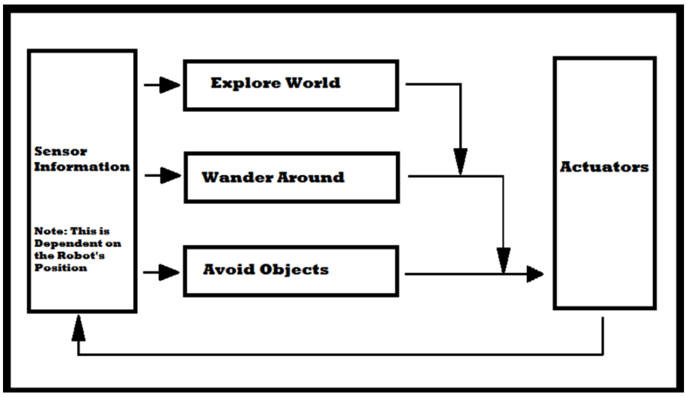

Fig. 1. Abstract representation of subsumption architecture, with the higher layers subsuming the roles of lower layers when the sensory information determines it. [1]

As shown in Figure 1, **three core functions** are

- **Subsumption Layers**: The behavior of exploring the world is divided into three hierarchical layers: Avoid Objects (lowest layer), Wander Around (middle layer), Explore World (highest layer). Higher layers subsume lower layers, meaning they can override their functions when necessary to achieve more complex behavior.
- **Sensor**: Continuously monitors the environment and feeds real-time signals to all layers simultaneously.
- **Actuators**: Execute actions based on which layers have been activated, ensuring appropriate responses to the environment.

It is this continuous interaction among these three functions—where layers react to sensor signals and trigger actuators based on defined conditions—that allows the system to behave in real time, without requiring centralized control or symbolic reasoning. As the robot moves through its environment, it continuously collects and integrates data from past interactions to adjust its behavior on the fly, identifying more effective paths and responses based on what it has encountered.

4 The Problem with Centralized Intelligence

Before Subsumption Architecture, robotics research pursued centralized intelligent systems that modeled the environment internally and attempted high-level strategic decision-making. However, these systems failed to perform reliably in dynamic, real-world environments. The complexity overwhelmed centralized models, and successes were limited to highly constrained tasks, such as developing a smart chess game. Recognizing this failure, Rodney Brooks proposed a radical new approach: **abandon com-**

plex internal models and focus on real-time environmental interaction through layered, autonomous behaviors. This breakthrough fundamentally changed the trajectory of robotics and adaptive systems design.

5 Subsumption in Nature: The Human Body as an Analogy

Subsumption Architecture mirrors the natural organization of the **human body**.
Our bodies are composed of subsystems that function autonomously most of the time:

- The heart beats rhythmically without conscious involvement.
- The lungs maintain breathing automatically.
- Reflexes, like pulling away from heat, occur faster than conscious thought.

The body's **Sensor** system (nerves, receptors) constantly monitors the environment. Subsystems (layers) act based on this input, with minimal centralized intervention. When anomalies arise, **signals** like pain surface and escalate control to higher cognitive functions. **Actuators** (muscles, organs) carry out necessary actions. This biological model illustrates why **layered autonomy, real-time sensing, and dynamic suppression** are so powerful. Structuring organizations similarly — with continuous sensing, autonomous layers, and decentralized real-time action — enables adaptability, resilience, and growth.

6 Agile Scaling through Subsumption

6.1 Building Blocks of Customer-Focused Organization

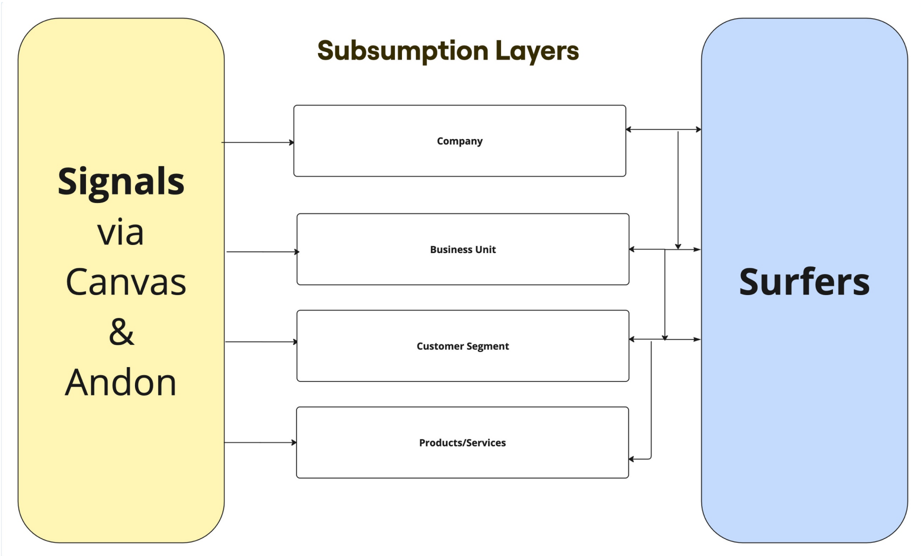

Fig. 2. Illustrating how Subsumption principles are applied to customer focused org. ecosystem.

- **Subsumption Layers**: The organization uses customer segments as the base to build its subsumption layers, resulting in five hierarchical levels: VC (top layer), Business Unit (2nd), Customer Segment (3rd), Value Proposition (4th), and Features/Services (bottom layer). Higher layers subsume lower layers, ensuring strategic alignment while preserving autonomy at its own layer.
- **Signals via Canvas & Andon**: Just as sensors provide real time data in robotics, business canvases and Andon-style signaling systems facilitate real-time information sharing and decision-making across layers.
- **Surfers:** Surfers move fluidly across layers, guiding decisions and optimizing workflows. Surfers are domain experts who move fluidly across teams and layers. They gather real-time information, assess emerging conditions, and coordinate actions across the organization. Surfers enable decentralized yet synchronized decision-making without relying on hierarchical command structures.
- **No Central Control**: Instead of relying on top-down control, Signals, Layers, and Surfers work together to maintain alignment and responsiveness at scale.

By embracing this model, organizations can embed agility throughout the entire system, ensuring speed, autonomy, and resilience in scaling.

6.2 Applying the Model: A Hypothetical eAuction Scenario

eAuction is a dynamic digital auction platform designed to serve multiple industries, beginning with airline ticket auctions and later expanding into entertainment, sports, and fine arts. As eAuction grew rapidly, the company needed an organizational ecosystem that could scale while preserving the speed and autonomy that made its early success possible. To achieve this, eAuction applied principles of Robotics Subsumption Architecture to its organizational ecosystem. Rather than relying on centralized management, the company structured itself into layered, autonomous teams capable of responding to real-time conditions such as ***market changes, customer needs, or internal tensions.***

Startup Phase: Building from the Bottom-Up Approach
In its startup phase, eAuction adopted a bottom-up approach to building its business, beginning with services tailored for the airline industry. The figure 3 below illustrates how Subsumption Architecture was first applied:

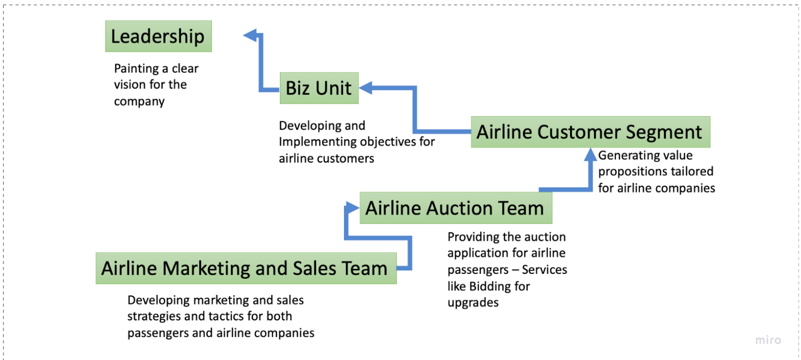

Fig. 3. eAuction's bottom-up approach of applying the subsumption architecture at the startupstage.

Starting with the Airline Marketing and Sales Team - developing marketing strategies and tactics for both passengers and airline companies, the organization layered upward through specialized teams: the Airline Auction team (responsible for services like bidding apps for ticket upgrades), the Airline Customer Segment team (focus on generating a portfolio of value propositions for the airline customers), and the Business Unit team (developing and implementing objectivities for airline customers). All of this was anchored by Leadership team, which painted a clear vision for the company. This bottom-up evolution exemplifies how autonomy and responsiveness were preserved while building toward strategic alignment.

Expansion Phase: Diversification and Structural Adaptation
eAuction has evolved from an airline auction platform into a dynamic, multi-segment marketplace. Today, it serves four key customer segments: Airline Companies, Music

Stars, Sports Leagues, and Artists**.** By structuring operations around customer segments, eAuction expands seamlessly while maintaining autonomy and adaptability.

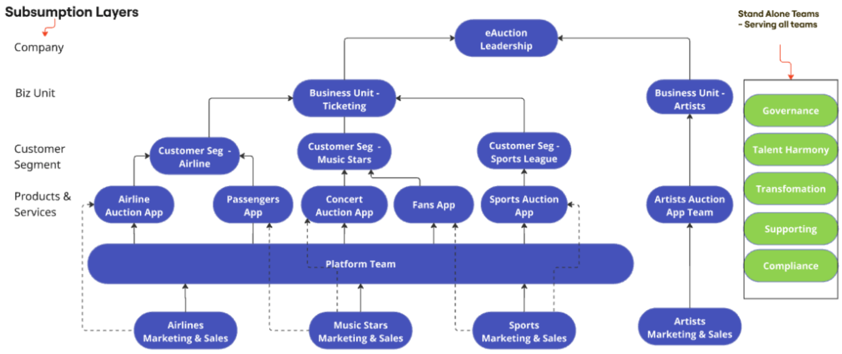

Fig. 4. snapshot of eAuction's Organization structure at the current stage of their growth.

Figure 4 illustrates how eAuction used customer segments as the base to build its subsumption layers. The four layers—Company/Leadership (top), Business Units (2nd), Customer Segments (3rd), and Products & Services (bottom)—reflect a structure grounded in customer needs. This foundation enabled eAuction to diversify while preserving focus and autonomy. The figure highlights the resulting diversified segment teams, a spun-off Business Unit dedicated to Artists, a centralized Platform Team for ticketing, and standalone service teams—such as Governance, Talent Harmony, Transformation, Supporting, and Compliance—that provide organization-wide support. Notably, eAuction spun off a distinct Artists Business Unit to serve the unique needs of creators who auction artwork rather than sell event tickets. This structural separation allowed for tailored value propositions, marketing, and applications—while preserving responsiveness through the subsumption model.

One important structural detail is the presence of a **Platform Team** that serves all auction-related product teams under the Business Unit - Ticketing. This includes the apps supporting airlines, passengers, music stars, music fans, sport leagues, and sports fans. However, the Platform Team does **not** serve the Artists Auction App team, as the nature of that business differs significantly—artists do not sell tickets but rather artworks, requiring separate tooling and workflow. Additionally, eAuction introduced a set of **stand-alone service teams—Governance, Talent Harmony, Transformation, Supporting, and Compliance**. These units operate outside of the subsumption layers and provide essential, shared capabilities across the entire organization. While they are not embedded within the business units directly, they enable the whole organization to function effectively and responsibly at scale.

The current organizational ecosystem for eAuction works through the integration of Subsumption Layers, Canvases, Surfers, and Signals—a triad that forms the foundation of its decentralized organization ecosystem. These elements don't operate in isolation; rather, it is the way they are glued together that enables the organization to function as a cohesive, adaptive whole. Surfers fluidly connect efforts across teams, and Signals and canvases provide constant real-time awareness. These mechanisms allow decentralized teams to respond rapidly and coherently without requiring central command. What we see in Figure 4 is a snapshot of eAuction's growth—a moment in time. As the company continues to expand, pivot, or respond to shifting market demands, their organization ecosystem is expected to evolve. For an organization to remain fast and agile, all components— teams, signals, surfers, and shared services—must work in concert to continuously adapt and align to emerging conditions.

7 Outcomes and Benefits

The application of Subsumption Architecture to Agile organizations can produce a number of tangible outcomes:

- **Autonomy at the Core**: Teams operate independently and make decisions locally without waiting for approvals—yet higher layers retain the ability to override when necessary to maintain strategic alignment.
- **Decentralized Decision-Making**: Subsumption layers promote decentralized control, dramatically reducing the friction and delays caused by traditional command-and-control hierarchies.
- **Happier Teams, Customers, and Stakeholders:** It fosters self-management, leading to more engaged teams, improved customer outcomes, and ultimately, satisfied stakeholders.
- **Survival and Profitability:** In today's complex and volatile markets, adaptability is essential. Subsumption Architecture enables organizations to respond rapidly to change—improving both resilience and profitability.

References

1. Brooks, R. (1999). The Early History of the New AI. *Cambrian Intelligence*, 8-12, 15-16.