Behaviorally Segmenting the Internet of Things (IoT)

"The Internet of Things is big. Really big. You just won't believe how vastly, hugely, mind-bogglingly big it is." - Misquote from The Hitchhiker's Guide to the Galaxy

The industry needed a useful, functional model of the Internet of Things (IoT) to frame recent developments in the space. But Moor Insights & Strategy could not find one that was sufficiently vendor-neutral, technology-neutral, and jargon-neutral, and at the same time, both simple to understand and comprehensive. This paper is a high-level summary of the model we created.

Charting Our Course

We like 2x2 charts because they force a level of simplification that targets the sweet spot for most people's working memory. The trick to creating effective 2x2 charts is to discover vertical and horizontal axes that adequately segment a topic at its highest levels while also providing deep insight into nuances.

The two main axes in our IoT map are **Impact** and **Control**.

We call the vertical axis "**Impact**." It describes the impact of technology on human well-being. It loosely follows Maslow's Hierarchy of Needs, which Maslow summarized as: physiological, safety, love, esteem, and self-actualization. After asking "what's love got to do with it?" and wondering how we'd measure it, we ignored love and focused on a span of more measureable human needs. These needs range from basic physiological requirements and safety to what many refer to as the "first-world problems" of esteem and self-actualization.

> "**Health and Safety**" describes systems that enable a baseline for a safe, comfortable life. In a modern, mature economy, this encompasses a range of small- to large-scale systems, such as generating and delivering power and clean water, eliminating sources of disease through waste disposal and sanitation, enabling transportation, and providing adequate heating and cooling at work and home.
>
> "**Experience**" describes systems that address emotional and aspirational needs related to personal status and performance, such as education, entertainment, fitness, and time, resource, and money management.

We call the horizontal axis "**Control**." It describes a range of control interactions that people exert on technology, from self-directed to interactive systems.

“**Self-Directed**” systems are purpose designed start-up and then operate with as little human interaction as possible. Some are effectively invisible to most of us in our daily lives, such as power generation and water sanitization, and others we respond to as part of the landscape, such as traffic lights.

“**Interactive**” systems are designed for constant and personal human interactivity and responsiveness. They are highly visible, and we notice their absence immediately, such as mobile telephony and cooking ovens and stoves.

Figure 1: IoT Landscape

Unlike others’ attempts to segment the Internet of Things, the Moor Insights & Strategy IoT construct is almost entirely defined by behaviors rather than by technology.

Segmenting Industrial and Human Internet of Things

In our segmentation, the difference between Self-Directed and Interactive is determined by how humans interact with the system’s rules, and vice versa.

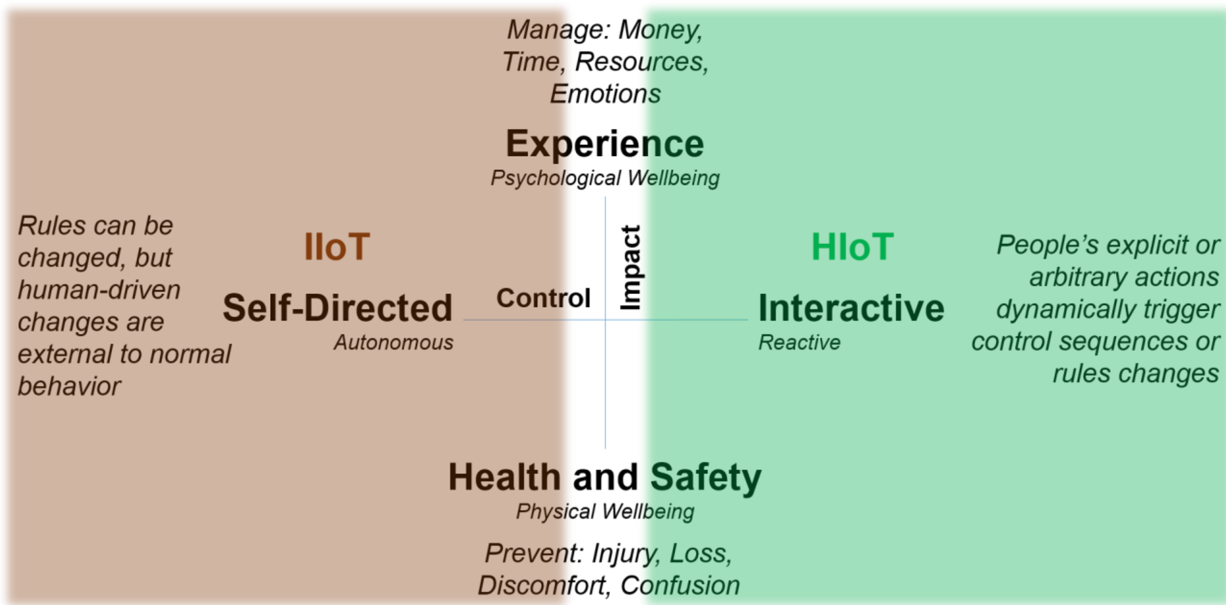
Self-Directed systems are designed to be operated by as few humans as possible. Rules are changed infrequently, they are only changed after careful consideration, and, increasingly, they are changed on-the-fly while a system is in full operation.

Interactive systems are designed for humans to change the rules frequently, and sometimes capriciously, either through downloading new rules (apps) or by devices and systems adapting to human behavior in real-time. Interactive systems are often inoperable while new rules are loaded onto a device, and we humans tolerate that behavior.

This division between systems that operate continuously by a set of rules and systems that interact dynamically with humans creates a useful distinction between autonomous "**Industrial**" systems and reactive "**Human**" systems. While the labels are not perfect, they are close enough to convey a lot of information without a lot of words or impenetrable jargon.

These labels help us with our top-level split on IoT: the **Industrial Internet of Things** (IIoT) and the **Human Internet of Things** (HIoT). We're going to use these terms in our follow-on IoT writing.

Figure 2: IoT Divided into Industrial vs. Human IoTs



Coloring the IIoT "Brown" and HIoT Opportunity "Green"

While their cloud-based service and Big Data / analytics back ends will continue to have a lot in common, IIoT end-points will remain different from HIoT end-points in measurable ways.

Land use terminology is instructive in describing these differences. **"Brownfield"** refers to a potential development site that has been already developed for industrial or commercial use, from an old factory turned into loft apartments or rails-to-trails. **"Greenfield"** refers to undeveloped land. Generally, IIoT is a brownfield opportunity, whereas HIoT is predominantly greenfield.

The IIoT seeks to connect more than a century of in-service mechanical and electrical systems to the Internet and therefore to new cloud-based services and analytics back-ends. For instance, there is a used market for decades-old building HVAC boilers like those made by Cleaver-Brooks – their 1970s models are easy to find. IIoT connects these brownfield retrofits with greenfield local connectivity and control protocols to new services layers.

HIoT opportunity is mostly greenfield, where there is much more scope and incentive to create new vertically integrated single-vendor ecosystems.

We'll dive into the details of these differences and market dynamics in future papers.

Table 1: Near-term end-point differences between IIoT and HIoT

Attribute	IIoT	HIoT
Market opportunity	Brownfield	Greenfield
Product lifecycle	Until dead or obsolete	Whims of style and/or budget
Solution integration	Heterogeneous APIs	Vertically integrated
Security	Access	Identity & privacy
Human interaction	Autonomous	Reactive
Access to Internet	Intermittent to independent	Persistent to interrupted
Response to failures	Resilient, fail-in-place	Retry, replace
Network topology	Federations of peer-to-peer	Constellations of peripherals
Physical Connectivity	Legacy & purpose-built	Evolving broadband & wireless

Identifying Switching Costs

"Switching costs" is an economic term used to describe the barriers a customer must overcome before they choose to shift their purchase of a product or service to a different supplier. Price, performance, quality of build or service, execution to schedule, delivery record and many other factors contribute to raising or lowering a customer's ability to leave a current supplier to purchase from someone else – or not.

We've noticed an inverse relationship between switching costs for sensors and switching costs for services at different points on the Impact spectrum (vertical axis).

We'll apply these terms to customers switching between functionally equivalent devices or services:

- **Fungible**: low switching costs; decisions are ephemeral and short-lived, making a decision to switch is easy and/or fast
- **Sticky**: high switching costs; decisions are persistent, making a decision to switch is difficult and/or lengthy

Mapping end-point devices, local connectivity, and services onto these quadrants leads to these observations:

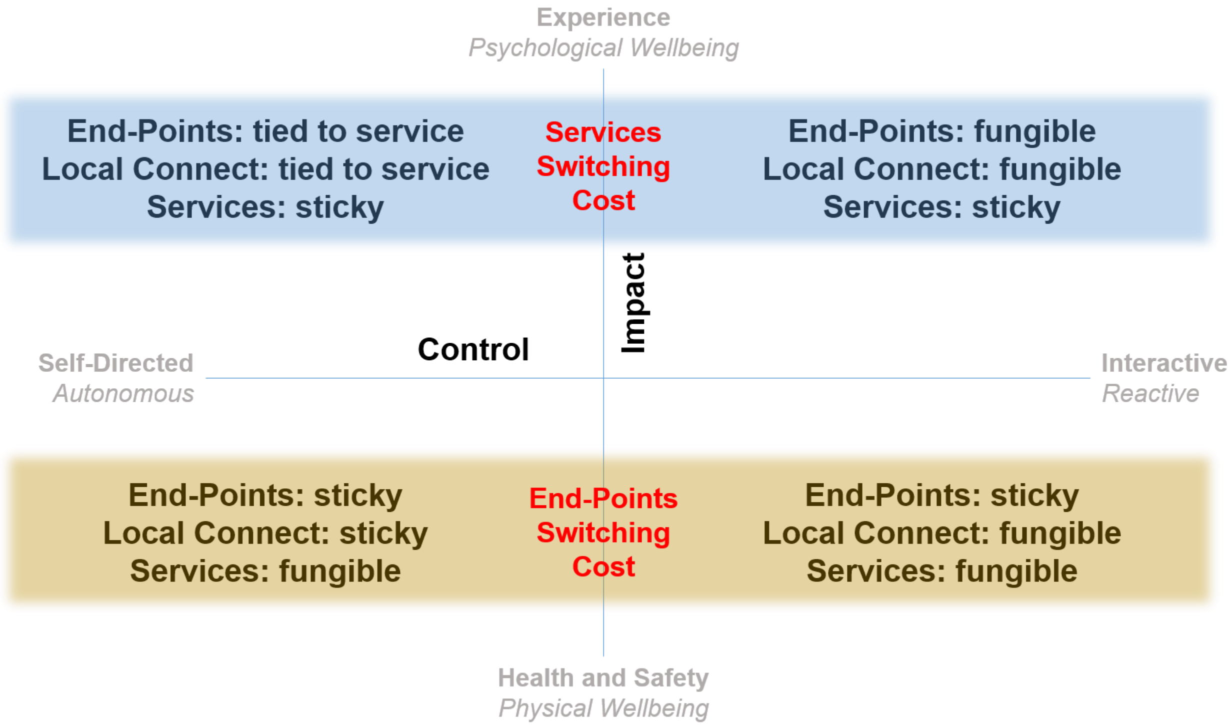
- End-points become stickier as they are embedded in purpose-built physical devices and infrastructure, typically owned or supplied by organizations. End-points are more fungible when they support individual Experience-based services. Consider sensors built into GE's jet engines and Whirlpool's dishwashers – they measure very specific attributes of a device that is designed for a focused purpose, they are incorporated into a product design and may or may not be designed into the next generation of the product. Building security systems (commercial and residential) are good examples of Experience-based services where the service selects and qualifies sensors they will install (embed) in a customer facility. A customer may choose from systems a service provider has pre-qualified, but the service provider is the systems integrator and ensures that all of the onsite sensors, aggregation points, and control systems work well together.

- Local connectivity doesn't quite track end-points for stickiness, but stickiness is closely related to Self-Directed systems and organizational ownership of products and services. Organizations tend to look at return on investment (ROI) differently than individuals, and this affects their expectations for product longevity and operational costs. Increasing Self-Direction in general means lower human labor costs. Interactive devices tend to be highly replaceable, even when they are relatively expensive. Product designers must pay attention to industrial design, user experience, and even color choices to create stickiness for each customer. While residential appliances perform repetitive tasks, they do so mostly when humans ask them to. The exceptions are devices like residential air conditioning and refrigerators which perform low-precision repetitive tasks that do not require a high degree of Self-Direction.
- Services are more complicated. They become stickier as people become emotionally attached to them and less sticky where organizations require return on investment (ROI). Services deployed by legislatively protected organizations (federal, regional, local) are sticky by default, such as power and water delivery. Organizational vs. personal ability to control service contract terms also plays a strong role, which overlaps with emotional attachment.

We see that a service model dominates when devices are discretionary, which is a function of how relatively easy they can be replaced. Cause and effect for device pricing are suspect when device prices are subsidized or completely hidden by the "rent" charged by the service. If I switch home security service providers, they will probably charge me a small installation fee and replace the previous sensors in our home, if it's not a clean install. But I won't pay full price for the sensors or the labor to install them because the service provider is giving me a free razor (sensors and control unit) and I pay for the blades (monitoring service). Home security is primarily on the industrial side because consumers typically don't buy the sensors and install them, a company does. Consumers buy a monthly dose of security. Consumers merely select from a menu of pre-qualified and inventoried equipment (typically "good, better, best" pricing options).

The key attribute separating the top two segments from the bottom two is that for the top half of the chart, end-points are almost always replaced when a service provider is switched for a functional equivalent. End-points in the bottom half are too expensive or too difficult to replace, and so service ecosystems will become the fungible component, if they are not already.

Figure 3: IoT Divided by Services Switching Cost

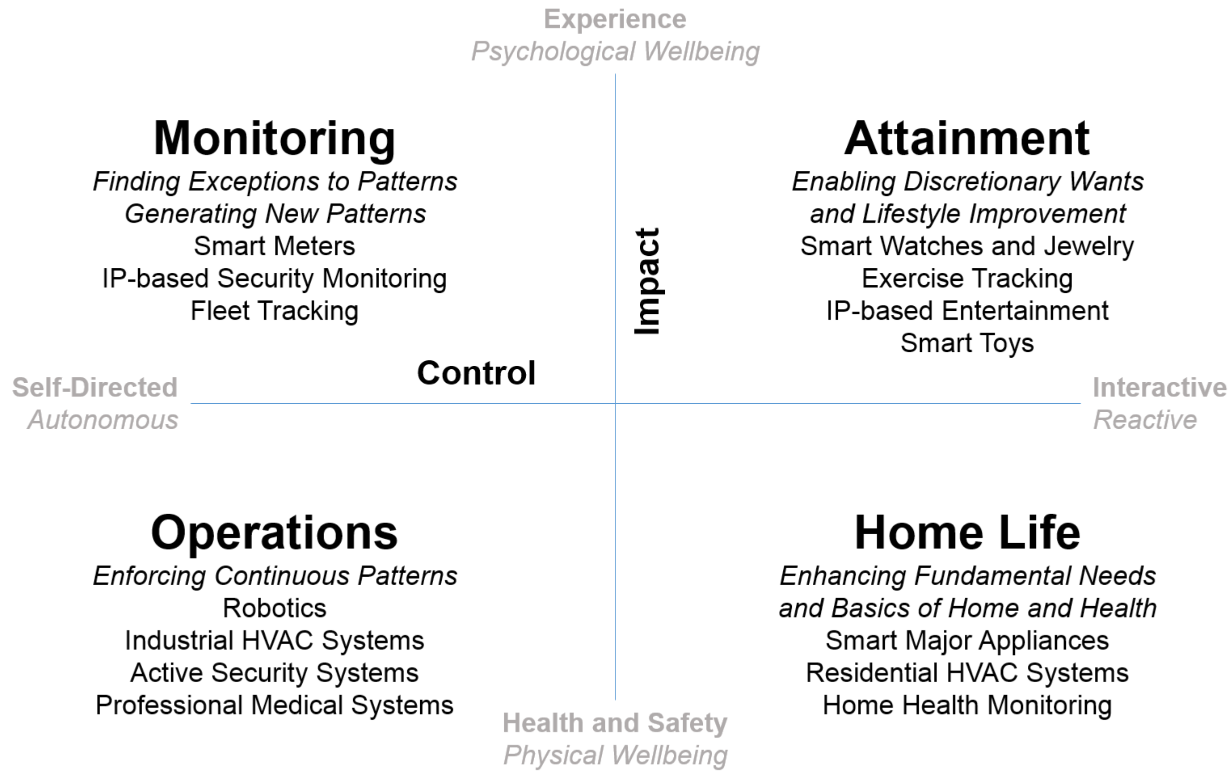


Segmenting the IoT Market

The interaction of these two axes on a Cartesian plane therefore produces four distinct IoT market segments:

- **Operations** – Perform high-risk and/or repetitive tasks
- **Monitoring** – Efficiently deliver and manage repetitive services
- **Home Life** – Improve people's day-to-day quality of life
- **Attainment** – Improve people's breadth and depth of experience

Figure 4: IoT Segments



We include short descriptions for each of these segments here, but we'll explore these IoT segments further in a future paper.

Operations: Repetition, precision, assurance. We depend on Operations devices to do a job, and we notice when they fail to do their intended job. There are human consequences when they fail – money, resources and/or time is lost, and perhaps human safety is compromised. Sensors and control capabilities are increasingly designed into Operations devices, or they are retrofitted into existing deployed devices. Factory automation and robotics fall into this category, as do the jet engines GE builds. These devices send a rich stream of sensor data to back-end analytics systems, which then preemptively alert maintenance techs that they require servicing.

Monitoring: Efficiency is conservation. Monitoring embeds sensors into our infrastructure, so that we can figure out what's happening. The sensor data is analyzed to figure out how to better maintain a system or to improve its efficiency. But these improvements are externally imposed on the local environment and most often are completely decoupled in time and methodology from the sensor systems used to gather system performance data. For instance, a building security system may determine that an intruder has entered the building, but the response is a police unit dispatched to confront the intruder. If the intruder alert is in fact a false negative, for example, if the person was authorized to enter the building but incorrectly flagged as an intruder, then external changes are typically made to the system to correct the misidentification. The only indication of changes may be new rules implemented in a cloud-based recognition service at a future date.

Home Life: Major appliances like refrigerators, residential air conditioners, dish washers and laundry washers and dryers, from manufacturers like Whirlpool and Bosch, automate more fundamental human needs. People use them every day as part of the infrastructure of their life. In a mature economy we need to wash and dry our clothes on a regular basis, have clean dishes, heat and/or cool the air, *etc*. These consumer devices are considered more of an investment than a discretionary purchase, because they are either big and heavy and relatively expensive to purchase, physically integrated into the structure of a residence and expensive and/or hard to install, or prescribed by a healthcare professional or system. Therefore, people want a longer useful product lifetime from these products.

Attainment: This is an aspirational segment, and in many respects this is a first-world segment – people spend their hard earned time and money on these products simply to feel good or to feel good about themselves. For example, fitness tracking systems like Fitbit's Flex, SYNC Burn, and Nike's Fuel start with a "wearable" HIoT bracelet that contains accelerometers and a simple device-control user experience. In Fitbit's case, the Flex device continually sends its accelerometer data to the owner's mobile device or PC via Bluetooth, and from there the data is sent to Fitbit's big data analytics servers via the client device's wireless connectivity. A summary of the owner's performance is sent back to their smartphone at the request of Fitbit's app, and that summary is also accessible via any device capable of browsing the web over any connection and can be shared with other services, such as RunKeeper. The owner may also change a few of the device settings and set vibration alarms through the smartphone app or through the web interface.

Home automation fits into the "Attainment" category, too. Vendors like Nest, Sonos, Korus, Honeywell, Hue, Insteon, and Revolv allow consumers to control lighting, door locks, garage door openers, HVAC, and distributed music, Although fun, informative and convenient, none of this strictly addresses human needs below the top level of Maslow's Hierarchy.

Note that all of these market segments are enabled by Intelligent Systems at some level.

Closing Words

Moor Insights & Strategy will conclude this introductory, high-level overview by observing that it is possible to segment complex sets of technologies and their interactions. We looked for differences in purpose and behavior, and two vectors emerged as key differentiators:

- **Impact** – Health and Safety vs. Experience
- **Control** – Self-Directed vs. Interactive

The four segments defined by the intersection of these vectors are easy to understand and describe a wide range of IoT systems and their value.

We will continue these threads in future papers and blogs. Our next Research Note on this topic will dive into the key differences between IIoT and HIoT.

Important Information About This Paper

Author
Paul Teich, CTO & Senior Analyst at Moor Insights & Strategy.

Editors
Scott McCutcheon, Acting Director, Research, at Moor Insights & Strategy.
Patrick Moorhead, President & Principal Analyst at Moor Insights & Strategy.

Inquiries
Please contact us here if you would like to discuss this report and Moor Insights & Strategy will promptly respond.

Citations
This note or paper can be cited by accredited press and analysts, but must be cited in-context, displaying author's name, author's title and "Moor Insights & Strategy". Non-press and non-analysts must receive prior written permission by Moor Insights & Strategy for any citations.

Licensing
This document, including any supporting materials, is owned by Moor Insights & Strategy. This publication may not be reproduced, distributed, or shared in any form without Moor Insights & Strategy's prior written permission.

Disclosures
No employees at the firm hold any equity positions with any companies cited in this documented.

DISCLAIMER
The information presented in this document is for informational purposes only and may contain technical inaccuracies, omissions and typographical errors. Moor Insights & Strategy disclaims all warranties as to the accuracy, completeness or adequacy of such information and shall have no liability for errors, omissions or inadequacies in such information. This document consists of the opinions of Moor Insights & Strategy and should not be construed as statements of fact. The opinions expressed herein are subject to change without notice.

Moor Insights & Strategy provides forecasts and forward-looking statements as directional indicators and not as precise predictions of future events. While our forecasts and forward-looking statements represent our current judgment on what the future holds, they are subject to risks and uncertainties that could cause actual results to differ materially. You are cautioned not to place undue reliance on these forecasts and forward-looking statements, which reflect our opinions only as of the date of publication for this document. Please keep in mind that we are not obligating ourselves to revise or publicly release the results of any revision to these forecasts and forward-looking statements in light of new information or future events.