Business Reinvention for Advanced Hardware Technology Companies to Embrace Multiple Meaningful Service Ecosystems

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ABSTRACT

Advanced hardware technology companies tackle some of the difficult problems in technology, but their key challenges include dealing with complicated technologies and regulations, the requirements for costly equipments, different ventures, long time needed to prototype and probe, *etc.* The financial viability and attractiveness of these companies would be more favorable if there could be repetitive revenue streams brought into the way in which the products or services are sold, through digital servitization to go beyond their one-and-done business models. This servitization could dig into the potential associations between the societal/environmental values and their economic progress so as to further leverage their hardware technology assets and launch future growth in terms of embracing meaningful service ecosystems. Our book (Business Reinvention on Ecosystem Value, Flexibility and Value) and our book's extended chapter (Business Reinvention for Resilience in the Post-Pandemic Era) have provisioned the fundamental methodology/models/tools. However, it is worthwhile to explore if a hardware technology product could also accommodate the distribution of multiple values (i.e., not designated to the distribution of only a single value) presuming a hardware product is not bounded with any designated values so as to advance the leverage increment of hardware capital assets. Accordingly, this additional supplementary paper aims to present such a systematic approach to enable multiple value distributions through a tangible hardware technology product (i.e., regarding a tangible product as a value-distribution hub of multiple meanings to yield a high leverage of hardware capital assets). Meanwhile, this paper will use an exemplar case company of advanced hardware technology to demonstrate the approach.

INTRODUCTION

Advanced hardware technology companies attack some of the tough issues in technology, like breakthroughs in engineering, computer science, biotech, and other disciplines. Herewith, hardware refers to the physical components that make up electrical or electro-mechanical systems and all the other things included that are genuinely tangible (e.g., consumer electronics, medical devices). The intricacy of advanced hardware technology working in the actual world implies that there are more noteworthy requirements for upfront investment but less adaptability on product-market fit. Their key challenges include navigating complex technologies and regulations,

the need for costly equipment and other investments, disrupting capital-intensive industries, long length of time required to prototype and probe, *etc.* The financial viability and attractiveness of these companies to investors or founders will consistently be more positive if there could be repetitive revenue streams along the way the products or services are sold.

In the golden days, most hardware companies have the so-called one-and-done business model, in which any end customer goes to the store, gets a product, pays for it once and it is finished (Lewis, 2012). For attaining recurring revenue streams, servitization has become a major significant change for hardware companies, in which servitization is regarded as a change progress from manufacturing hardware technology products to adopting new business models of service provisions (e.g., maintenance, product usage consultation) in order to meet customer needs and repetitive revenue streams.

That is, servitization of hardware manufacturing is a trend of growth model which involves manufacturing companies bringing progressively more service components into their offerings. Recently, digitalization can further help servitization of hardware manufacturing on setting out new open doors for creating new opportunities for new services, intelligent products, or novel business models (Lerch & Gotsch, 2015; Parida, Sjödin, & Reim, 2019; Porter & Heppelmann, 2014). Successful implementations of digital servitization of hardware manufacturing often extend operations past the limits of a single company or a single industry into business ecosystems, which emphasizes value creation and capture among interrelated companies (Kohtamäki et al., 2019).

On the other hands, as a company reopens and recalibrates after a turbulent time like the COVID-19 pandemic, it's worth asking whether it should resume business as usual or whether its true purpose should instead be reconceptualized to the extent to which it is fit for the challenges and opportunities of the present and future. Perceiving and exploiting the connections between the societal/environmental and the economic progress could unleash the potentials of launching future growth development and reinforcing/broadening future capitalism to harness wider benefits to the company and the prosperity of the society/environment (McKinsey, 2020).

Accordingly, the strategic leverage of existing advanced hardware technology assets in response to unpredictable unfavorable occasions is an important resilient ability for companies to survive or even thrive in light of the presence of possible negative impacts. Krogh et al. (2020) called this resilient ability as ultrafast innovation that repurposes the existent assets, knowledge, resources and technologies to cope with the negative impacts or crises. This resilient ability is totally different from typical stock-keeping-unit expansion referring to the expansion of various types of a similar product to serve diverse market segments (Shih, 2020). In addition, the extent of capital leverage could be unfolded in different levels (say low, middle and high) which means the magnitude of the

possible ways of leveraging capital assets behind a variety of service provisions created to meet the market needs (Yuan, 2020b).

For moving beyond advanced hardware technology manufacturing to embrace a meaningful service provision to increase the leverage of existing hardware capital assets, our book - Business Reinvention on Ecosystem Value, Flexibility and Value (Yuan, 2020a) - and our book's extended chapter - Business Reinvention for Resilience in the Post-Pandemic Era (Yuan, 2020b) - have provisioned the fundamental methodology/models/tools. However, it is worthwhile to explore if a advanced hardware technology product could also accommodate the distribution of multiple values (i.e., not designated to the distribution of only a single value) presuming a hardware product is not bounded with any designated values so as to further advance the leverage increment of hardware technology assets. Accordingly, this supplementary paper would first highlight some background materials previously mentioned in our book and extended book chapter, followed by the presentation of such an enabling approach that could facilitate the development of multiple value distributions through the provision of a hardware technology product. Next section will then discuss these issues and the approach. An exemplar case of advanced hardware technology company (an electrophoretic ink company temporarily called Xink) would also be used to demonstrate the approach.

THE EXEMPLAR HARDWARE BUSINESS CASE

XInk is an inventor of electronic ink and creates Electronic Paper Display (EPD), using electronic ink laminated to a plastic film and then adhered to electronics. Eelectronic ink actually is a fusion of chemistry, physics and electronics, and like paper it utilizes the same pigments used in the printing industry. XInk's technology is regarded as bistable referring to the fact that an image on a XInk screen will be retained even when all power sources are removed. This means that a XInk display consumes power only when some content is changing. The XInk display is a reflective display, in which no backlight is used and ambient light from the environment is reflected from the surface of the display back to people's eyes. In addition, XInk displays are plastic-based TFTs that allow the end products to be substantially lighter and thinner than products using fragile glass-based TFTs. That is, the use of plastic-based TFTs can result in more rugged end products with less breakage in the electronics due to drops.

With the aforementioned advantageous changes in XInk's technology, its worldwide EPD market share reaches its high dominance with their advanced hardware technology development and device manufacturing, currently creating promising yearly revenue while hoping for expanded market revenue similar to that of Active Matrix Organic Light Emitting Diodes (AMOLED). On the part of shared value, XInk basically manufactures eco-friendly products as far as its dominated

electronic readers sold, each of which is thought to be stacked with somewhere around 10 books that would then yield the saving of magnificent tree deforestation and the elimination of large amount of CO2 from the environment for one tree engrossing 21.7 KG's CO2. Nevertheless, digital servitization of XInk could further move beyond its one-and-done business model and the EPD industry boundary so as to embrace more meaningful service ecosystems.

BACKGROUND CONNECTING TO OUR BOOK'S BUSINESS REINVENTION METHODOLOGY

To increase the strategic leverage of existing hardware capital assets of an advanced hardware technology assets, this requires the company's workforce to be empowered to leverage their capital assets on which the active behaviors of meaningful service provision could be designed and created so as to address the connections between the societal/environmental and the economic progress on behalf of the company. Our book (Yuan, 2020a) and our book's extended chapter (Yuan, 2020b) have provisioned the fundamental methodology/models/tools and the followings show some extracted background highlights.

The business reinvention methodology (Yuan, 2020a) could be briefed as an iterated design process that consists of value design (i.e., topics about design challenge, value space boundary, empathy map & data contradiction analysis, association reasoning, reframing & synthesis, POV, *etc.*), ecosystem design (i.e., topics about value exchanges & configuration, ecosystem actors sensemaking, strategic ecosystem flexibility, *etc.*), ecosystem operation design (i.e., topics about ecosystem operational strategy choices, ecosystem's digital solution architecture & digital operants, digital business, *etc.*), business reinvention viability & business model, and business reinvention strategy, and so forth.

Centering to a value space is a triggering point that calls forth the value design process. There are two types of triggering points as depicted in Figure 1: (1) intangible soft design challenge (e.g., challenging problem features of relevance to Quality of Life) and (2) tangible hard technology or product (e.g., provocative features of relevance to the particular technology, product, or service). Given a trigger, the designated value space would roughly signal the attempted business priority of a focal business in the face of disruption, threats, or innovations.
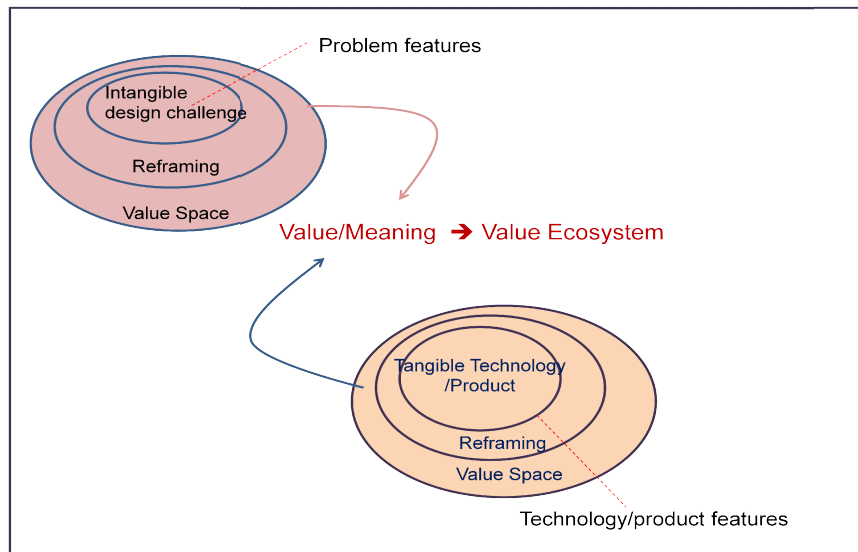
Figure 1. Triggering points that call forth the value design process (Yuan, 2020a)

For cultivating an existing business' resilience capability regardless it being capital heavy or capital light, our book's extended chapter presents an approach that could be exercised in either a simple way or a comprehensive way as briefed in the followings (Yuan, 2020b):

1. **Business core/side value/function incorporated with Reframing Stretches (RS):**

    A business' core/side value/function could be extended using the five types of association reasoning (context, analogy, contiguity, contrast, and similarity as shown in our book's Chapter 3, Table 3) to uncover different types of Reframing Stretch (RS), which help identify the potential capital asset leverages of designated shared values. If a side value/function chosen, chances are the extended side shared value/function and capital asset leverage could become the business' future core value/function.

    For typical value design (our book's Chapter 3), reframing associations aim at uncovering resolutions for indentified data contradictions, or called reframing resolutions. As depicted in our book Chapter 3's Figure 24-25, the resolution discovery process iterates by combining what I SAW (i.e., those identified contradictions) and what I KNOW (i.e., better explanations behind the contradictions in terms of changing the perspectives via reframing out of new frames identified).

    Simplifying the aforementioned process, reframing stretch (RS) is defined as the attempts to uncover possible capital leverages in terms of stretching out to new perspectives by which the capital assets could be viewed and the likely capital asset leverage could be generated (Yuan, 2020b). As depicted in Figure 2, this is conducted by iterating the combination of what I SAW (e.g., pandemic-related needs) and what I KNOW (e.g., likely capital asset leverages behind

the needs in terms of stretching out new perspectives by which existent capital assets could be viewed in relation to the needs via the associations).
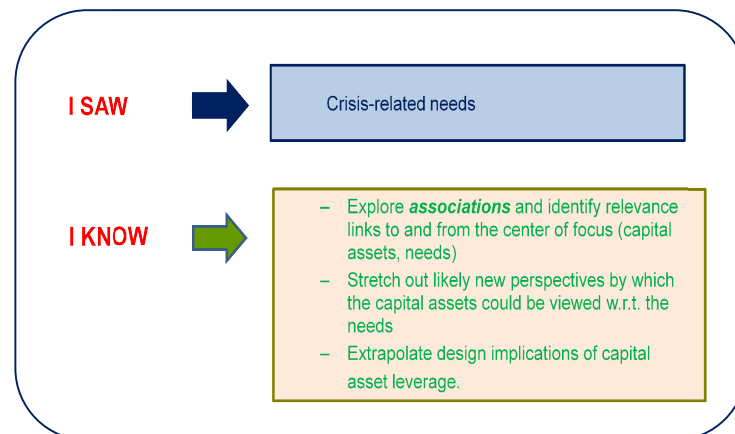

Figure 2. Reframing stretch (RS) (Yuan, 2020b)

2. **Business core/side value/function incorporated with the societal/environmental value space boundary to attain a new shared-value-based design challenge, followed by an implementation of our book's whole business reinvent methodology to drive innovative reinvention:**

The resilient element of shared value embodies the designated value space of the strategic directions complying with the societal or the environmental (as depicted in our book Chapter 3's Figure 11). To attain meaningful innovation, a business core/side value concept could incorporate the societal/environmental value space boundary to attain a new shared-value-based design challenge that serves as the triggering point calling for the whole business reinvent process (as depicted in Figure 1).

Here is an exemplar company being incoporated with the imagined shared-value space boundary so as to identify new shared-value-based design challenges, which could uncover innovative reinvention with the implementation of our book's whole business reinvention methodology afterwards:

Tesla + Societal Boundary: an exemplar design challenge could be "How could vehicle of automated transportation delivery become vehicle of societal wellbeing delivery?"

The lack of coping resilience for companies isn't only the prompt loss of revenue from slowed or disrupted operations. The greatest danger would originate from not observing the accelerated changes of mega trends and taking advantage of the opportunities of transforming themselves to generate new products and services that are either tending to the unpredictable crisis needs or addressing the latent/implicit needs. Our book's business reinvention methodology could also

provide companies with a set of tools/methods/models to cultivate the abilities of resilience or reinvention.

Successful applications of business resilience reinvention vary in different business/industry contexts, and the strategic planning of business resilience could likewise be developed by stages as those discussed in our book's Chapter 8. Any business attempting to reinvent itself could move from inward to outward indirectly or directly until its maximum business resilience point (i.e., the round orange point shown in Figure 3). A business resilience strategy refers to their strategic choices for paving the way to do indirect and direct movements towards maximum business resilience.

The strategic choices for these indirect and direct movements include the choices between the aforementioned two approaches of cultivating business resilience capability (i.e., business core/side value/function incorporated with reframing stretches, or business core/side value/function incorporated with the societal/environmental value space boundary to attain a new shared-value-based design challenge and then implement our book's whole business reinvention methodology).
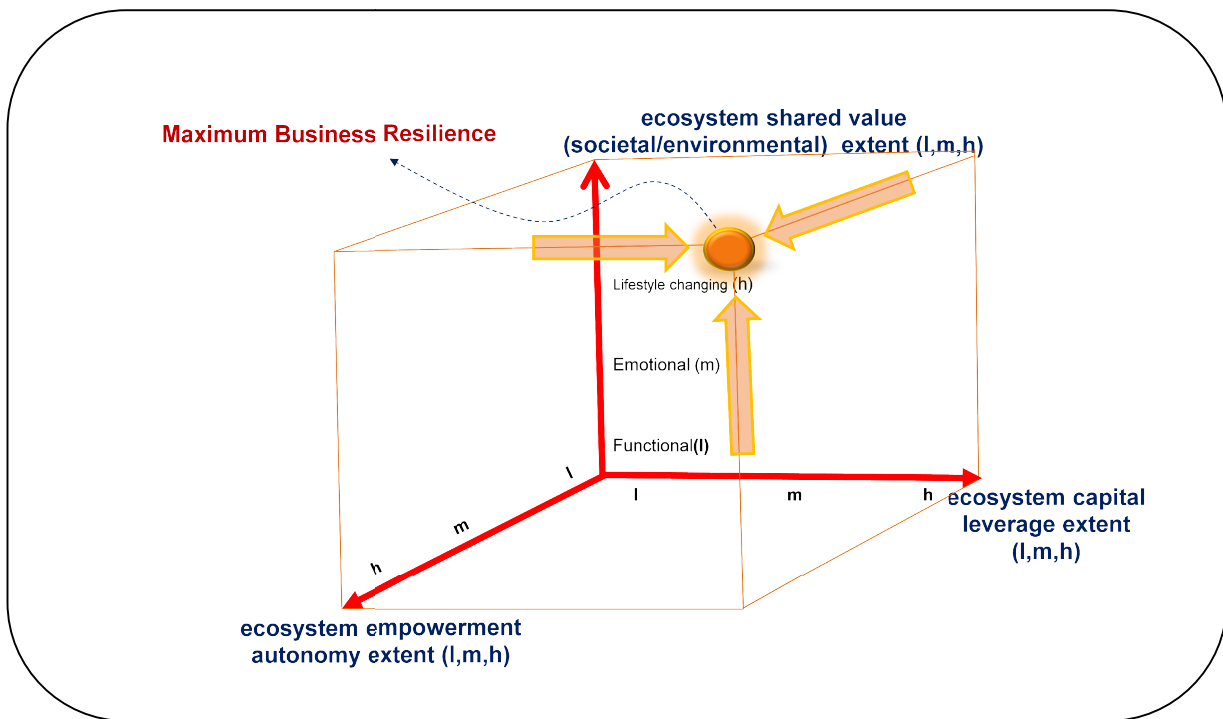

Figure 3. Conception of business resilience strategic planning (Yuan, 2020b)

In the service/experience/shared-value economy, services are sometimes provided indirectly through the provision of tangible technology products, i.e., a tangible technology product could be regarded as a value-distribution media device for service provision (Vargo & Lusch, 2016). The

aforementioned methods could help develop a meaningful service ecosystem indirectly through a value-distribution media device of tangible technology product by well-designed digital servitization. Nevertheless, it is worthwhile to explore if a value-distribution media of hardware technology product could also accommodate the distribution of multiple values (i.e., not designated to the distribution of only a single value) presuming the media is not bounded with any values? If yes, is there a systematic approach to facilitate the development of multiple value distributions through a tangible technology product? Next section will discuss these issues and the approach. Hereinafter, the terms of meanings and values are used interchangeably.

MOVING BEYOND HARDWARE TECHNOLOGY PROVISION TO ACCOMODATE MULTIPLE MEANINGFUL SERVICE ECOSYSTEMS

The previous section highlights our previous research's design-oriented methods that could move advanced hardware technology business to embrace a meaningful service ecosystem, i.e., regarding a hardware technology product as a value-distribution media device for service provision of a single value (Vargo & Lusch, 2016). How about considering the media device to be capable of accommodating the distribution of multiple values (i.e., a value-distribution hub of multiple values), resulting in a higher asset leverage of the media device usage? This section then aims at exploring such feasibility and presents a corresponding resolution approach.

To become a value-distribution hub of multiple meanings from a tangible technology product, it is imperative to first understand the core features of the tangible hardware technology product prior to the search of meaningful service provisions that could use the tangible hardware technology product as a distribution media of potential meaningful values. Meanwhile, to achieve a higher leverage of the media device usage, the conceptual process of abstraction could be applied to these identified technology core features in order to derive technology general features for uncovering greater possibilities of hardware technology applications.

Abstraction could be regarded as a many-to-one function, and it helps map many subordinate-related concepts to one super-categorical concept that often features a higher or deeper innovation level and greater market potentials because of the crossing conceptual applicability to other problem domains one by one as depicted in Figure 4 (Yuan, 2020a), which will potentially yield a greater set of applicable meanings (i.e., a greater media-specific meaning hub space). With those core and general feature concepts attained, what follows would be a searching process of applicable meanings that could view a tangible technology product as a feasible media device to distribute these meanings. Meanwhile, these identified meanings are preferably to be flexibly managed and assessed in accord with the hardware technology provider's business considerations. The above-mentioned accordingly manifests the conception about the transitions

of a hardware technology product from value/meaning media to media-specific hub of meaningful service provisions with well-designed digital servitization and flexible media-specific meanings management as depicted in Figure 5.
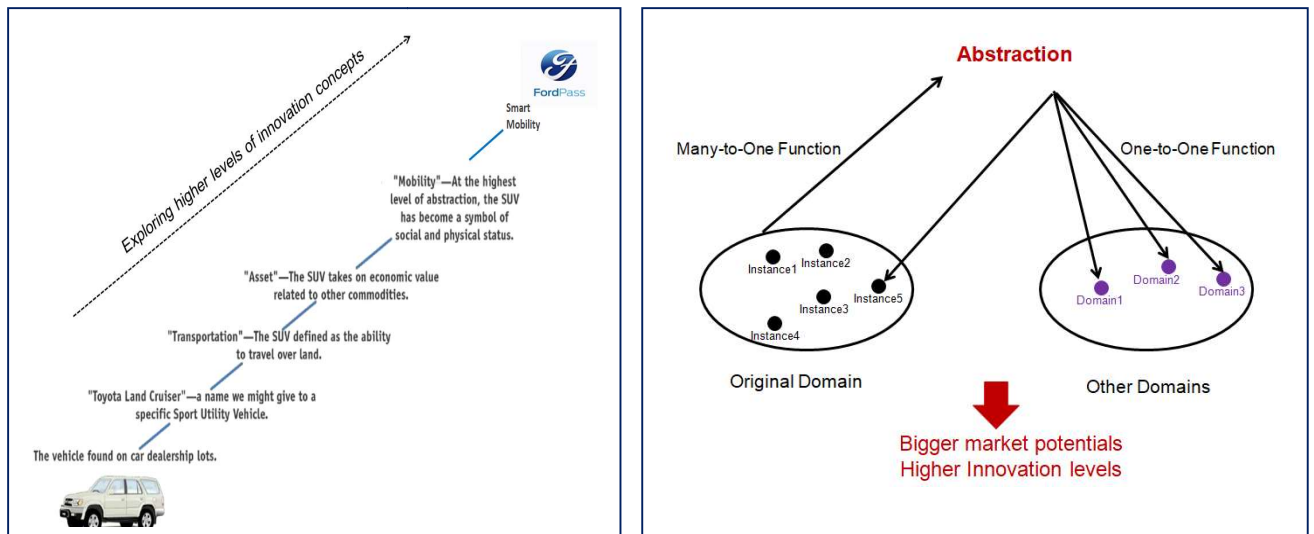

Figure 4. Exemplified power of abstraction to explore greater sizes of market potentials (Yuan, 2020a)
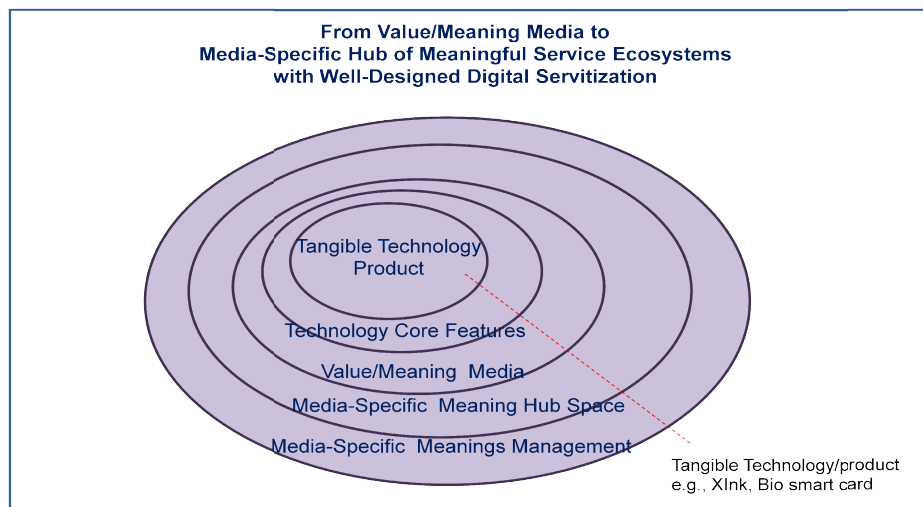

Figure 5. The transitions from hardware technology media to media-specific hub of meaningful service ecosystems

To realize the above-mentioned transitions, as follows shows our approach's development steps (Figure 6), as exemplified by the XInk case company:
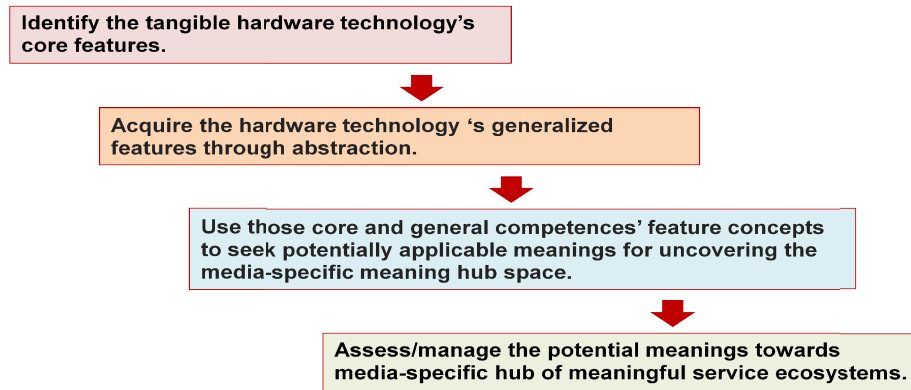
Figure 6. The enabling approach

1.   Identify the tangible hardware technology's core features.

When a tangible hardware technology product could be used as a potential value distribution media, this means its core features are capable of realizing potential fundamental competences required by some service provision. That is, when considering the exemplar hardware company XInk, it is to uncover XInk technology's fundamental competences.

To characterize the underlying technological competence, Danneels & Frattini (2018) proposed the idea of de-link a technology from its specific products in which it is currently used. To do this, companies need to identify the functions the technology can perform. This exercise gives managers a way to explore the technology's characterization and begin to imagine new applications. A good characterization can broaden the scope of the potential opportunities and get managers to focus clearly on the technology's abilities and limits. For example, a robotic arm that can move in multiple directions would have the core feature as the ability to position objects in space; additional features may include the abilities of performing along multiple dimensions (e.g., force, precision, speed, range, and energy consumption).

Adopting the de-link idea to the exemplar case of XInk, the core features could then be identified as rugged/green/cheap/automated content display. The underlying rationales include: the display on a XInk's EPD consumes power only when something is changing; XInk EPD uses no backlight but ambient light from the environment; XInk EPD uses Plastic-based TFTs sustainable/thinner than fragile glass-based TFTs leading to being more rugged in case of drops or stress tension.

2.   Acquire the hardware technology's generalized features through abstraction.

When exploring to accommodate multiple meanings for a tangible hardware technology product media, abstraction could be exerted to derive general competences' feature concepts of the tangible technology so as to yield a greater media-specific meaning space.

Adopting the conceptual process of abstraction to the case of XInk's core features (rugged/cheap/green/automated content display), the followings are exemplar general competence features attained:

Rugged/cheap/green automated content display →

Rugged/cheap/green real-time continued content manifestation →

Sustainable/affordable multimodal content manifestations **(cognitive/emotional/behavioral)** →

Sustainable/affordable multimodal interactions' manifestations towards various meaningful empowerments (e.g., optimal/safe/wellbeing) → and so on …

3. Use those core and general competences' feature concepts to seek potentially applicable meanings for uncovering the media-specific meaning hub space.

Those core and general competences' features of the tangible hardware technology entail a media-specific meaning hub space, in which a searching process of applicable media-specific meanings (i.e., viewing a hardware technology product as a feasible media to distribute these meanings) could be deployed. This step could employ an IT-based sense-making tool, Discover+ (Yuan & Hsieh, 2015) to assist on the searching.

Discover+ could help designers facilitate their search of meaningful insights based on the data attained from the data of interviews or observations, and the above-identified core and general competences' features could be analogical to the interviews/observations data without loss of generality. This tool mainly comprises three parts – theme finding, frame finding and insight encoding (Yuan & Hsieh, 2015).

Accordingly, theme finding could assist with discovering themes based on the above-identified core and general competences' features. Theme finding uses the knowledge in ConceptNet (Liu & Singh, 2004; Shen et al., 2007), a numerical statistic method Term Frequency-Inverted Document Frequency - TFIDF (Salton and Buckley, 1988) and extra external supportive information search by means of Google Search API to perform context oriented thinking to look for most plausible themes of problem domains (i.e., a sense making process).

ConceptNet is a machine-comprehensible commonsense knowledge base that was structured as a network of natural language fragments that computers could know about the world (Liu and Singh 2004). The representation of ConceptNet is a directed graph. Each assertion can be viewed

as nodes connected by edges. Nodes are words or phrases that represent concepts and edges are relations of associated concepts as illustrated in Figure 7. For example, Figure 7 shows that a 'person' at location of a 'restaurant' which is used for 'satisfying hunger' while a cake (a kind of 'dessert' with 'sweet' taste) is also used for 'satisfying hunger' and the 'person' 'desires' 'desert'.
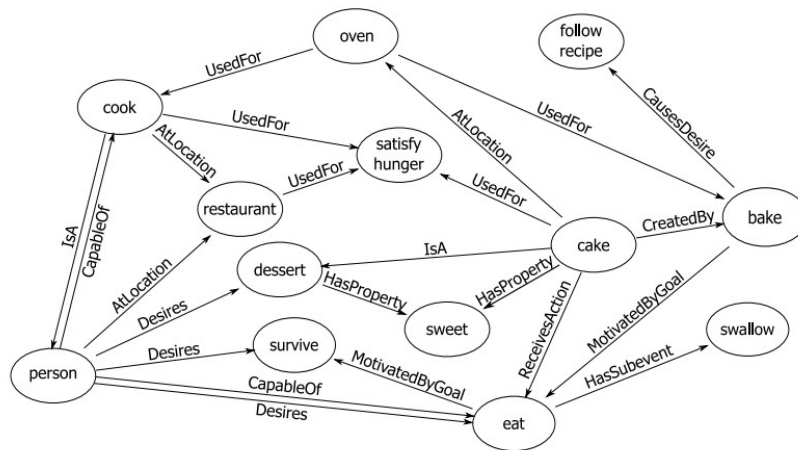

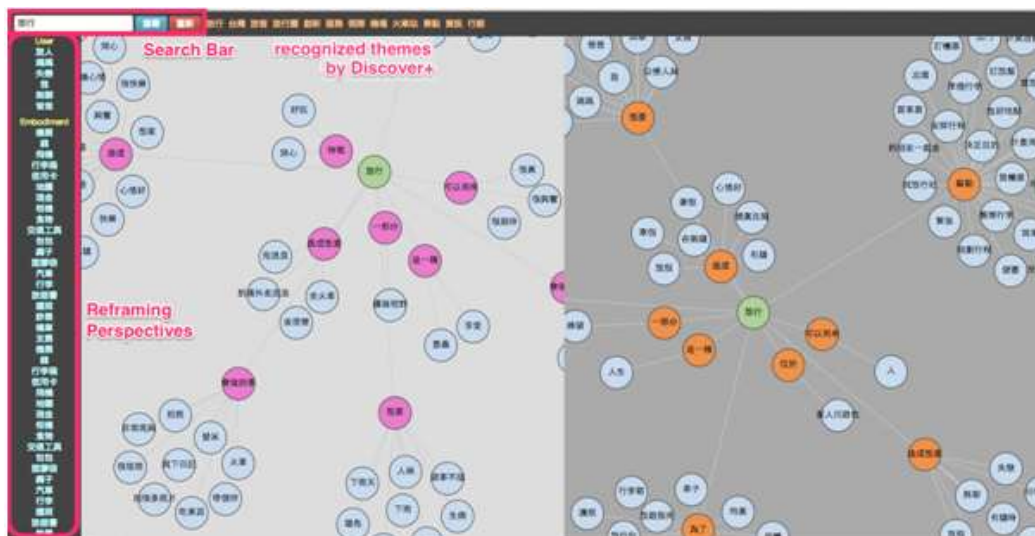**Figure 7.** Exemplar knowledge of related concepts in ConceptNet (Speer & Havasi, 2012)

Figure 8. Interactive interface of the frame-finder of Discover+ (Yuan& Hsieh, 2015)

Frame finding could then help find and build frames that are relevant to the identified themes through various kinds of association reasoning, followed by reframing to see the circumstance from new perspectives, as depicted in the tool's interface Figure 8 (Yuan & Hsieh, 2015). Frame finding includes four classes of frame searching, user perspectives, environments, embodiments and user goals as suggested by Kolko (2010). Each class of frame searching also uses the knowledge of ConceptNet. For example, 'gym' is connected with 'hotel' through the 'AtLocation' edge, and 'athlete' is connected with 'gym' by the 'Desires' relation. Therefore, it very well may be

deduced that athlete may be a potential user of hotel. Plus, when considering athletes, it could likewise be derived that kids who love sports might have similar requirements of hotel facilities. Conversely, impaired individuals who move with troubles ought to be thought about when designing services in hotels. By making similarity and contrast associations, designers can discover various types of possible user perspectives. On the other hand, using contiguity associations can likewise assist designers with discovering more potential user perspectives. For example, when viewing the service from the perspectives of a student, designers may contemplate the perspectives of a teacher, a secretary, or a librarian. That is, the tool can assist with accomplishing a rundown of suggested likely users through the association reasoning.

Insight encoding is then to produce insights with the results of framing and reframing. A good insight ought to contain these three fundamental parts (the user, their needs and the reason they need something) - *{user perspective}* needs *{design challenge}* because *{user goal, environment, embodiment}*. Users can be those suggested user perspectives. The things users need would then be suggested based on the recommended user goal, environment and embodiment. As for the reason, designers can be inspired by the recommended user goals. As per this, designers are suggested to follow the format shown below to complete the insights. For example, an insight generated state: "Travelling businessmen need to have a good bathroom use experience in a hotel because a party-like bathroom with energetic music can eliminate their tiredness after a day of conferences."

Each encoded insight is then regarded as a meaningful value of which the acceptance judgment is based on the strategies and priorities of businesses, in particular, the consideration of the lifestyle-changing shared value within the societal/environmental strategic context as shown in Figure 3. For the example of XInk technology business, one of myriad meanings could be exemplified as follows:

> *"The aging people need sustainable/affordable smart display that enables multimodal interactions' manifestations anywhere in neighborhood because various forms of wellbeing towards successful aging in place could be achieved interactively through cognitive/emotional/behavioral empowerment manifestations in one's own home and community."*

4. **Assess/manage the potential meanings towards media-specific hub of meaningful service ecosystems.**

For a hardware technology provider's business, as indicated in Table 1 there could be different strategic considerations in light of multiple potential meanings (i.e., hardware media devices through which service values being realized): (1) media device w.r.t. meaning being a 1-to-Many

relationship (2) media device's personalized usage being shared across multiple meanings vs. media device's public usage being shared across multiple meanings (3) media device and meaning being regarded as operant resources that could produce effects as emphasized in Service-Dominant Logic (Vargo & Lush, 2016).

Meaning Media Device	1 to 1	1 to Many
Personalized	Media device's personalized usage being deployed for a single meaning	Media device's personalized usage being shared across multiple meanings
Public	Media device's public usage being deployed for a single meaning	Media device's public usage being shared across multiple meanings

Table 1. Strategic relationships between media device usages and potentially applicable meanings

Being operant resources, either media device or meaning is capable of acting upon other (operand/operant) resources to co-create effect (Vargo & Lush, 2016). Accordingly, it is assumed that each meaning has a meaning owner (i.e., the owner of such designated meaningful service ecosystem) to co-creatively manage the meaning's relevant stakeholders or operant resources. Similarly, it is presumed that a media device can co-creatively manage the device's relevant meanings.

Accordingly, it is preferred for a hardware technology provider to have a structured way to flexibly assess and manage the interactions of media devices and meanings that are in accord with business strategic considerations towards the development of multiple value distributions through the provision of tangible technology product (i.e., media-specific meaning management).

To this end, a media device could be encapsulated with a well-designed software wrapper so as to exhibit the following meaning-independent goal, behaviors, benefit metrics and implementation:
- Goal - sustainable and quality access of media device for myriad meanings' fulfillment.
- Behavior -
  - Managing the media-specific meanings: the creation/deletion/updating of meanings that access the media device, possibly together with those media-access meanings' designated stakeholder types.
  - Managing the relationships among media-specific meanings: the registration of the connections among meanings that access the media device (i.e., cataloguing related meanings versus unrelated meanings).

- Monitoring the media-access meaning status: observing the media access by either related or unrelated meanings, possibly together with the types of meanings' stakeholders accessing the media device.
- Controlling or optimizing media-access meaning status: proactively providing analytics for meaning owners' decisions on media access.

- Benefit metric -
  - Satisfaction of (related or unrelated) meanings' fulfillment through accessing (personalized or public) media devices.
  - Media-device access diversity of meanings' fulfillment.
  - Media-device access leverage of related meanings fulfillment, in which the leverage depth could consider the related meanings' stakeholder-type levels and the related meanings' strategic levels (e.g., a higher leverage of media-device access through increased societal wellbeing achieved from various wellbeing-related meanings being fulfilled via the media devices), similar to the idea of insight depth as addressed in Yuan & Hsieh (2015).
- Implementation – each media device can be wrapped with some API wrapper (i.e., the above-mentioned software wrapper) of an open-meaning media-access mechanism, such as using session tokens (Tencent, 2021) calculated from a media-specific meaning hub located at the media-device owner's digital infrastructure (platform-based or blockchain-based).

In short, moving beyond tangible hardware technology provision the aforementioned enabling approach is believed to be able to facilitate the development of multiple value distributions through the provision of tangible hardware technology product and transform a tangible hardware technology business into a media-specific hub business accommodating multiple meaningful ecosystems. In the next section, the exemplar case of XInk will be used to demonstrate its potential transformation from selling its one-and-done tangible hardware technology products to embracing multiple related meaningful ecosystems of relevance to the topic of successful aging in place.

AN EXEMPLAR CASE OF REINVENTING HARDWARE TECHNOLOGY PROVISION INTO EMBRACING MULTIPLE MEANINGFUL VALUE ECOSYSTEMS

To better demonstrate how to make the exemplar XInk hardware technology business to become a media-specific hub of multiple meaningful ecosystems of relevance to successful aging in place, this section will first brief the relevant global risk context about the necessity of successful aging in place, followed by a brief rationale and demonstration behind the development of multiple value distributions about successful aging in place through the provision of XInk tangible hardware technology products.

Relevant Global Risk Context

Population aging and urbanization are the culmination of successful human development during last century, and accordingly making urban areas more age-friendly is a fundamental reaction to keep urban areas flourishing in this century. They likewise are major challenges during the current century. Living longer is the fruit of general wellbeing and in ways of life. The economics of aging well would be valued at multi-trillion dollar targets, specifically for individuals born in wealthier countries being bound to invite wellbeing interventions that further develop wellbeing, improved health, and deduced mortality and make aging well a health priority, for the example of an estimate of $37 trillion in present worth terms in the United States (World Economic Forum, 2021).

Meanwhile, Fiebig (2021) gave a famous quote "age does not diminish the supreme disappointment of having a scoop of ice cream fall from the cone". This implies individual traits don't vanish when individuals turn 65 (versus being viewed as the people category of "the elderly"). Hence, making urban communities more age-friendly is a vital and coherent reaction to advance the wellbeing and commitments of older urban residents and keep urban communities flourishing.

Obviously, many urban aging societies have embraced policies that formulate aging-in-place, and home- and community-based services have begun to escalate, giving new choices to the individuals who need help with the continuation of a somewhat independent life in their places and who would prefer not to move into a long-term care facility (Figure 9). Meanwhile, institutional care is significantly more costly than the arrangement of care in the community and at an older individual's home according to the viewpoint of policy makers (Chappell et al. 2004; Kaye et al. 2009). The high public cost on nursing-home care impulse policy makers just as experts to provide alternatives to serve fragile older adults in their communities. Accordingly, policy makers and general society have gotten attuned to the longing of older people to age in place (Kubu, 2018).
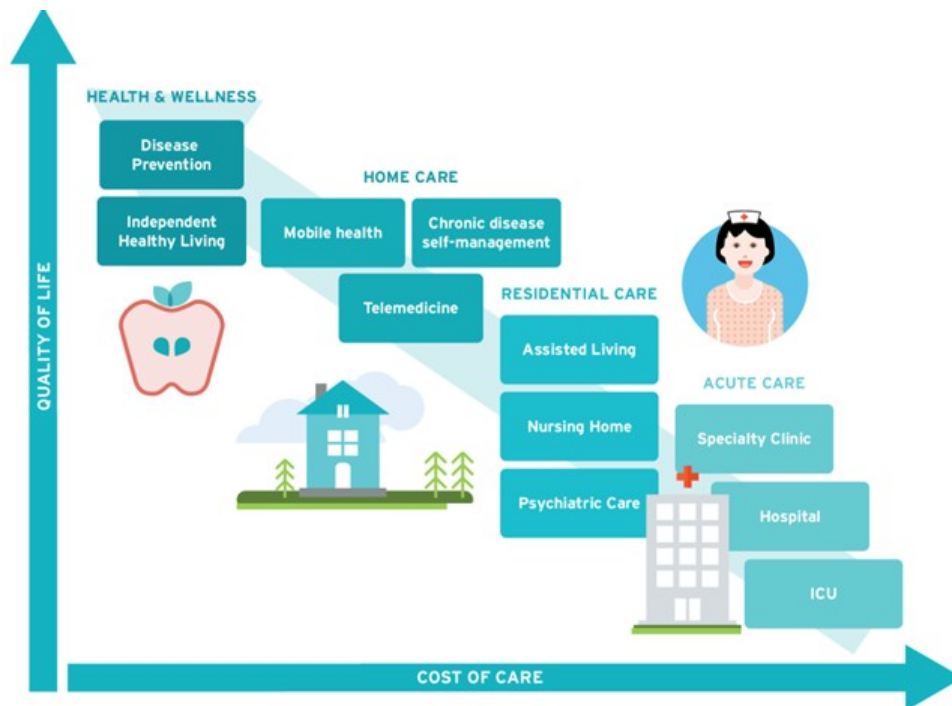
Figure 9. Health 2.0 trends and threads (Kubu, 2018)

Shared Value on Successful aging in Place

The majority of older people want to age in place, to stay as self-governing, active, and independent as long as possible and live at home surrounded by family and friends (AARP, 2011). Self-governance comprises of decisional control and decision in molding one's life; institutional care is viewed a last resort. The transition to senior residential housing and later to a long-term care facility are frequently the consequence of insufficiencies of the home to meet the changing requirements of older people due to decline in health and self-care capacities, loneliness, isolation, accessibility barriers inside the home and in the surroundings, and unavailability of essential services, a poor quality of care, and the risk or fear of crime and violence in perilous neighborhoods.

Rowles (1983, 2017) devised a theory of insideness to conceptualize attachment to place, identified with three measurements: social insideness for being in promimal to the families and friends, physical insideness for having a sense of environmental control because of living somewhere for long periods, and autobiographical insideness for the attachment to a place due to the recollections that shape self identity. Subsequently, urban successful aging in place refers to the ability to live in one's own urban home and community safely, independently, and comfortably.
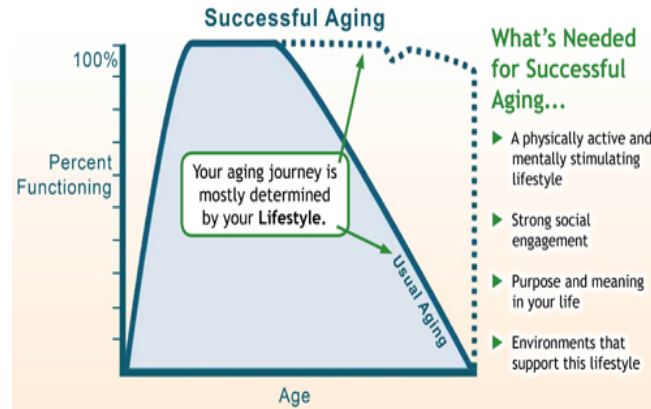
Figure 10. The MacArthur Foundation Study shows how the lifestyle choices that older individuals make determine their health (Rowe & Kahn, 1998).

A milestone ten-year study by the MacArthur Foundation has clearly shown that 70% of physical aging and about 50% of mental aging are determined by the lifestyle and the choices individuals make every day. Instead of being a cycle of consistent decrease, aging can be a time of growth if older individuals keep up with their physical and mental abilities, lessen their danger for sickness and injury, and stay productive and engaged with life as depicted in Figure 10.

However, the challenges of existing aging-in-place tools (as exemplified in Figure 11) are fairly fragmented and lack of an integrated approach towards a meaningful life in form of the physically and mentally stimulating lifestyles. For example, an assisted living residence or assisted living facility is a housing facility for people with disabilities, and these facilities provide supervision or assistance with activities of daily living, coordination of services by outside health care providers, and monitoring of resident activities to help to ensure their health, safety or wellbeing.

Accordingly, the gaps and opportunities then rest on the understanding of an older individual's purpose & meaning in life, his/her physical/mental/social wellbeing status and personalized goal of successful aging in forms of enabling, stimulating, and facilitating the interactions with on-demand integrated actors and operant resources towards the older individual's proper life style. Meanwhile, any possible solution deployment also needs to consider Individualism as well as scalability.
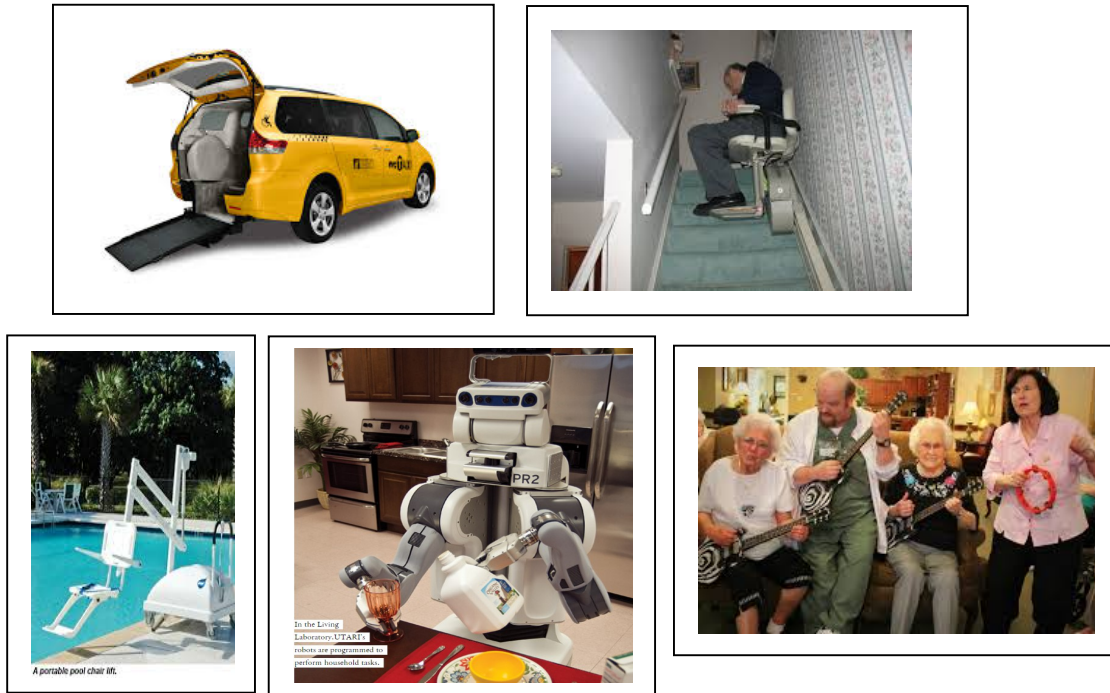
Figure 11. Exemplar existing tools for exercising aging in place

XInk Media-Specific Hub of Multiple Meaningful Ecosystems towards Urban Successful Aging in Place

The Rationale

XInk technology's core and general competences' feature concepts include sustainable/affordable multimodal interactions' manifestations **(**cognitive/emotional/behavioral**)** towards various meaningful empowerments, and so on. With the previously-mentioned approach of seeking potential meanings to uncover the potentials of media-specific meaning hub space, it will lead to various problem domains and meaningful values, covering a variety of user perspectives and their corresponding user goals/insights. Exemplar perspectives include the aging seniors, the city governments, and the fitness professionals, each of which presumably has their meaningful service ecosystems (hereafter named SuperAgers, SmartHappiness, IngeniousFitness). In light of the aforementioned societal shared value of successful aging in place, the relevant global risk context and high market potentials, XInk is assumed to decide that it would strategically embrace these three meaningful ecosystems through distributing these meaningful values via the value-distribution media of XInk devices so as to accelerate the leverage of their hardware technology assets. The followings will then show XInk's strategic thinking and the deployment of the enabling approach.

The Underlying Philosophy

To demonstrate how to facilitate the development of multiple successful-aging-in-place value distributions through the provision of XInk tangible technology products, it is better to first understand its underlying philosophy, which includes the followings: an older adult's life is defined by his/her aspirations, experiences, strengths and abilities; the older adult is the expert in his/her own life; aging is a natural variation and a function of interactions between the older adult and the environment; society must change to be more accessible and respectful of the older adult. Accordingly, effective strategies and interventions should be properly designed and offered to promote health and well-being lifestyle for succesful aging in place (i.e., physical, mental and social well-being in senior's own home and community).

Regarding proper interventions, there are various participation structures regardarding health and well-being lifestyle in terms of various types of activitiy participations - O2O (online to offline), B2C (service provider to customer), B2B2C (service provider to service provider to customer), SoLoMo (social/local/mobile), P2P (peer to peer), *etc.* The idea of customer value maximization through personalized wellbeing interventions during the aging over time is argued to be a feasible strategy for guiding such proper intervetions. Any meaninful ecosystems could be designed to embody these various types of activity participations involving cross-sector actors engaged and integrated towards meaningful interactions towards customer value maximization. Moreover, it would be even better that those meaningful interactions could also facilitate community-based social capital generation as this would subsequently reinforce physical, mental and social well-being in senior's own home and community. That is, achieving customer value maximization (as formulated in Figure 12) through personalized wellbeing interventions, older adults are interactively engaged with properly calculated interventions toward value maximization during the aging over time.

Figure 12. The conception of wellbeing value maximization formula

Representing superior value of wellbeing elements - PERMAV

To further detail the components of the wellbeing value besides the typical physical's vitality element, the elements of the PERMA flourishing model (Seligman, 2012), which is a popular model in positive psychology and has been used in several wellbeing studies (e.g. Forgeard et al., 2011;

Cameron, 2012; Park, 2014) (as depicted in Figure 13), are argued to well suit our end. The rationales are shown as follows:

- Positive Emotion: It means positive senses, such as pleasure, comfort, good, happy, satisfied, *etc. (*Seligman, 2012). Positive Emotion has been considered as an important factor towards flourishing by many positive psychologists (Maslow, 2013; Ryan & Deci, 2001; Riff, 1989).

- Engagement: It is related to the sense of flow, which means one is completely self-less absorbed in activities (Csikszentmihalyi, 1997). People may focus on what they are doing and feel time passing quickly when they are in flow.

- Relationship: It indicates one's authentic connection with others (Seligman, 2012), and it is a critical factor of realizing wellbeing (Grootaert *et al.*, 2003). Through measuring social capital online and offline, it would be easier to understand people's relationship situations for achieving social wellbeing (Antheunis et al., 2015).

- Accomplishment: It represents the sense of accomplishment and success in one's pursuits. Additionally, achievement is strongly linked with purpose and pursuit of important goals, which are the vital components of life meaning (Park, 2014). That is, a high degree of Accomplishment could be achieved when the goals and purpose in life are well pursued.

- Meaning: It expresses one's purposeful and meaningful sense (Seligman, 2012). Meaning in life has been widely recognized to be of great importance in psychology, even in recently popular positive psychology, leading to wellbeing. Steger (2013) stated that the influences of Relationship and Achievement depend on the characters of each individual, which is affected by his/her personal strengths. In addition, Achievement is related to goals and purposes pursuing, which also are covered by Meaning (Park, 2014). Engagement and Positive Emotions cannot stand alone without meaning pursuing (Steger, 2013). Accordingly, Meaning could be regarded as the central foundation of the wellbeing concept.

- Vitality: It denotes wellness health, which represents one's physical and phschological status. Other than being frequently viewed as an essential wellbeing element in comparison with the other wellbeing elements, vitality is even more important among seniors. For example, the prevalence of four chronic conditions has increased significantly among baby boomers, including cardiovascular disease, obesity, lung problems, and diabetes (Martin *et al.*, 2009).
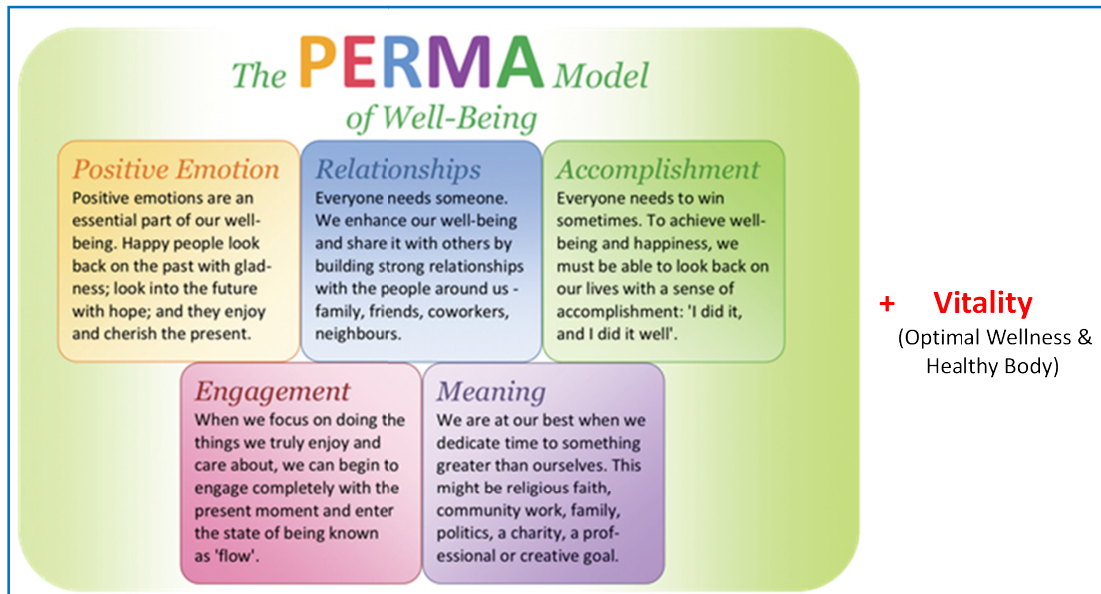
Figure 13. Core elements of wellbeing value (Seligman, 2012)

Figure 14 then shows the above-mentioned wellbeing elements further extended with additional subordinate elements, strength and activity, for facilitating the wellbeing measurements and proper interventions of activities towards wellbeing value maximization on successful aging in place. The main ideas rest on strength-based interventions through activities because strength-based interventions have been shown to lead to positive wellbeing effect (Segerstom, 2001). That is, positive interventions refer to treatment methods or intentional activities aimed at cultivating positive feelings, positive behaviors, positive cognition, *etc.* As follows are the further explanations of these subordinate elements:

- Strength: Identifying and developing Strengths can help individuals keep pursuing goals (Segerstom, 2001) and identify meanings and purposes (Sweeney, 2014). Accordingly, strength is argued to be capable of serving as a subordinate element of the underlying meaning.

- Activity: Therapeutic recreation has been developed for a long time in positive psychology. It means that specialists utilize one's leisure experiences to enhance Strength and reach the goals, i.e., meaning and purpose in life (Anderson and Heyne, 2012). Accordingly, activity interventions could analogically be viewed as leisure interventions provisioned to individuals and help them reach their final goals in life. That is, Activity could also be argued to be capable of serving as a subordinate element of the underlying Meaning.
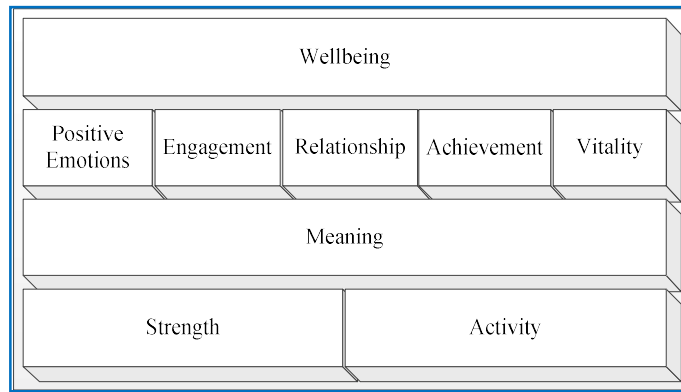
Figure 14. Activity interventions considering wellbeing core elements and extended subordinate elements

XInk Media-Specific Hub

XInk attempting to serve as the successful-aging-in-place media-specific hub, the required efforts have two folds – the hardware media-device part and the software API part embodied with the above-mentioned underlying successful-aging-in-place philosophy. The hardware media-device part includes public/private media devices (presumably augmented with additional necessary sensing sensors), each of which is wrapped with some APIs that would enable an open-meaning media-access mechanism, using calculated session tokens (Tencent, 2021) attained from a media-specific meaning hub located at XInk's digital infrastructure (platform or blockchain). The software APIs part then encompasses a system embodying the above-mentioned underlying philosophy and wellbeing value maximization model, hereinafter referred as the SuperAgers service ecosystem.

Figure 15 depicts a persona - an older adult, suffering from knee pain but possessing the outdoors-type personality, often wears a personal health watch and enjoys the participation of the outdoor activities at urban local community parks. Supposing there are several different kinds of public/private XInk media devices deployed in this persona scenario, say a private XInk wearable device (connected to XInk's SuperAgers meaningful ecosystem), public XInk park space media devices (connected to a city-government's SmartHappiness meaningful ecosystem, a IngeniousFitness service ecosystem, *etc.*). It is preferred that a set of operant actors (including "place" like community parks, community friends, *etc.*) could properly interact with each other in order to create various resource integrations tailored to the persona's successful aging lifestyle.
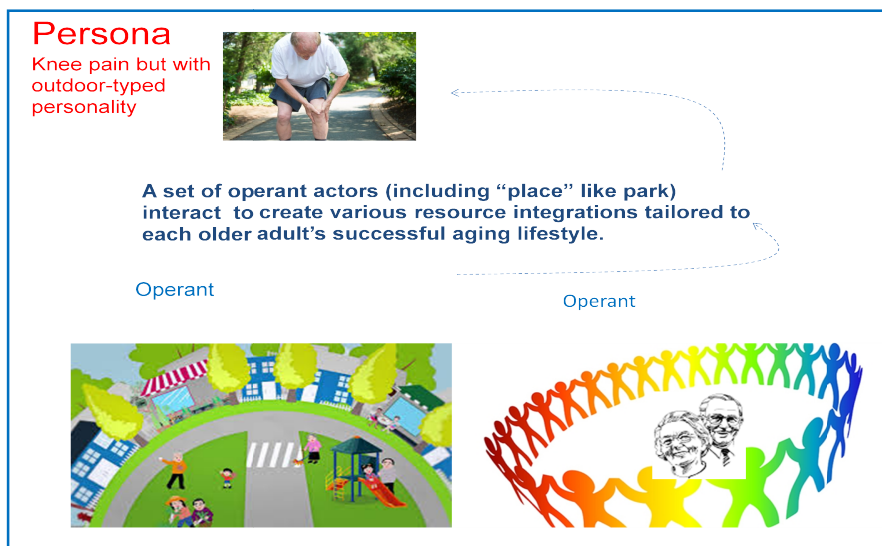
Figure 15. An exemplar persona

For the example of a public XInk park space device located at the persona's nearby community park, its behaviors could then encompass the followings:

- Managing the public XInk park space device's media-specific meanings: the registering of meanings (SuperAgers, SmartHappiness, IngeniousFitness) that access the park-space media devices, together with those media-access meanings' stakeholder types.

- Managing the relationships among the public XInk park space device's media-specific meanings: the maintenance of the connections among the related meanings (SuperAgers, SmartHappiness, IngeniousFitness) that access the park-space media device.

- Monitoring the public XInk park space device's media-access meaning status: observing the park-space media device accessed by these related meanings together with the types of their stakeholders accessing the media device.

- Controlling or optimizing the public XInk park space device's media-access meaning status: providing proactive analytics to the meaning owners of SuperAgers, SmartHappiness and IngeniousFitness for their decisions of relevance to the park-space media access.

Herewith is a scenario of the persona (Figure 16). When the persona entering a vacant community park, he would be recognized by the park's public XInk park space media device's registered SuperAgers and SmartHappiness ecosystems. Via the park-space media device, the SuperAgers ecosystem then recommends activity bundles (e.g., knee squats, air walker machine, *etc.*) together with activity interventions of proper strength levels based on his wellbeing maximum objective at this situation. The SmartHappiness ecosystem would also alert nearby community senior residents and encourage and increase their possible intents of exercise participations by means of fostering social connection with the persona (when they aren't in the habit of engaging in regular physical exercises towards improved community senior fitness) (HUR, 2021). When a

suitable size of seniors gather in the community park, the registered IngeniousFitness ecosystem would then alert suitable nearby community fitness trainers and solicit their potential interests of coaching those appearing seniors on some fitness exercises either online through the public park-space media device or the offline in-person instructions.

Figure 16. The ecosystems of SuperAgers, SmartHappines and IngeniousFitness registered at the community park-space media device
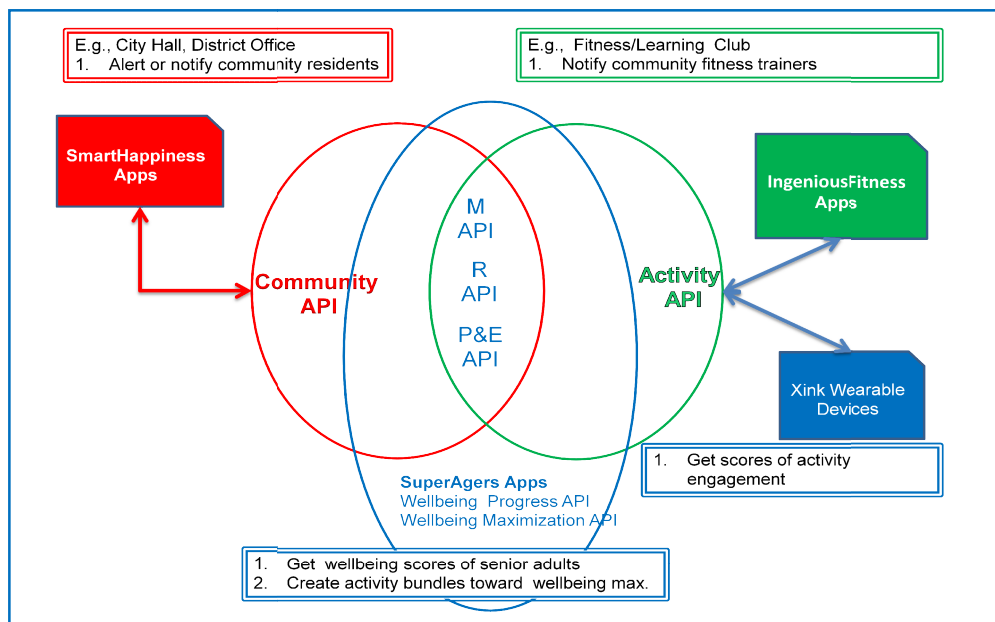

Figure 17. Three categories of involved APIs associated the three registered ecosystems - the blue-line oval (SuperAgers), the red-line oval (SmartHappiness) and the green-line oval (IngeniousFitness)

Figure 17 depicts the above-mentioned scenario together with the three categories (blue/red/green ovals) of involved APIs, of which different categories of APIs associated with different registered ecosystems represent the interactions among the persona, the community senior residents, the related ecosystems and the private/public media devices. That is, these APIs are utilized to facilitate the on-demand interactions among integrated actors and operant resources towards urban successful aging in place. These interactions also manifest various participation types - O2O, B2C, B2B2C, SoLoMo, P2P, *etc.* - among cross-sector stakeholders towards successful aging in place.   For more details of those APIs, exemplar implementations could be found in our former research works (Hsieh & Yuan, 2015; Wang & Yuan, 2015; Liao & Yuan, 2015; Wei & Yuan, 2015).

In addition, for the example of a public XInk park-space device located at the persona's nearby community park, its benefit metrics could then include the followings:

- A potentially high satisfaction score attained from the persona and the community senior residents about these related meanings fulfillment through accessing (personalized or public) media devices because of the realization of their PERMAV health interventions.

- A potentially high media-device access leverage of related meanings fulfillment because of a lifestyle shared value attempted together with wide categories of stakeholders involved.

- A potentially high media-device access diversity of meanings' fulfillment because of each media device wrapped with a software wrapper so as to easily and flexibly manage diversified meanings and their behaviors by means of the wrapper working with the media-specific meaning hub located at the media-device owner's digital infrastructure.

LEADERSHIP ROLES FACING ACCELERATING HARDWARD TECHNOLOGY LEVERAGE IN THE DIGITAL ECONOMY

The past decade ended up being a decent one for the hardware technology manufacturing industry, particularly for ones exhibiting digital savviness on execution and outcomes. Yet, other than the normal B2B supply-chain tradeoffs between contending objectives of cost and service level, COVID-19 has brought about enduring impacts on societies and companies due to rapid-changing customer demands, unpredictable trade barriers, political instability, natural disasters, just as the pandemic. These issues have made supply chain optimization more challenging than ever before. Nevertheless, the current key to B2B success would lay on moving from cost to shared-value service and partnership within the changing market context that offers a wide scope of affordable new digital technologies (Baue, 2020). That is, the transformation of B2B, which used to be founded on trust and confidence, started making an incentive for moving beyond existing business boundary and will just speed up in the digital economy. This would then be in line with the mega trend of hardware technology manufacture creating the differentiated shared value in the digital economy.

Figure 18. Four key leadership mindsets for success in the digital economy (Ready et al., 2020)

Accordingly, the involved mindsets of the B2B leadership for successful transformation in the digital economy could move from Producer mindset towards Investor mindset, Connector mindset or Explorer mindset as indicated in Figure 18. Although the producer mindset is of the attention on customer analytics and manifests digital savviness, execution, and outcomes, leaders with an investor mindset seek after a higher reason past investor returns. They care about the communities in which they operate and are determined to working on improving quality of life. They give close consideration to not just the products they are selling, services they are offering, yet in addition why they exist as organizations (Ready et al., 2020).

On the other hands, leaderships of the Connector mindset are of the authority of connections, partnerships, and networks that are another currency in an undeniably connected world. They routinely unite diverse stakeholders to accomplish a common purpose. Organizations whose leaders have an explorer mindset frequently encourage failure, invert mentoring and a profound interest in how the powers of digitalization are reshaping the competitive environment. They are interested not just about driving customer and customer community value, but about clarifying and pursuing their organizations' societal value as well (Ready et al., 2020).

For moving beyond tangible hardware technology provision by developing multiple value distributions through the provision of tangible hardware technology products in the digital economy, the required leadership mindsets would need to move from Producer mindset towards the

combination of the Investor mindset, the Connector mindset and the Explorer mindset. These leadership mindsets altogether could direct the transformation of a tangible hardware technology business into a media-specific hub business encompassing multiple meaningful ecosystems, accelerating hardware technology asset leverage.

CONCLUSION

Digital servitization has begun to help unfold the strategic leverage of an advanced hardware technology company's existing capital assets in response to dynamic customer demand, the unpredictable unfavorable occasions, the recurring revenue streams and the societal/environmental shared values attempted, in terms of exploring meaningful service ecosystems. To this end our previous research works have provisioned the fundamental design-oriented methods, when regard a hardware technology product as a value-distribution media for service provision for a single meaning. But for a higher asset leverage of the media usage, this supplementary paper then provides an enabling approach to develop multiple value distributions through the provision of tangible technology products to realize a value-distribution hub of multiple meanings (i.e., media-specific hub of meaningful service ecosystems) and media-specific meaning management.

This enabling approach views multiple media-specific meanings from well-structured but different perspectives: (1) media device w.r.t. meaning being a 1-to-Many relationship (2) media device's personalized usage being shared across multiple meanings (3) media device's public usage being shared across multiple meanings (4) media device and meaning being regarded as operant resources, i.e., either media device or meaning being capable of acting upon other (operand/operant) resources to co-create effects. That is, each meaning has a meaning owner (i.e., the owner of such designated meaningful service ecosystem) can co-creatively manage the meaning's relevant stakeholder/operant resources; likewise, each media device can co-creatively manage the device's relevant meanings towards proper media-specific meaning management. These structured perspectives and the enabling approach are believed to equip the leaders of advanced hardware technology companies to discover and judge the multiple potential value distributions through the provision of tangible technology products in a more organized way in light of the economic uncertainties and the societal expectations. An exemplar case of advanced hardware technology business (XInk) is also used to demonstrate the approach, considering multiple related meanings and personalized/public media device uages towards urban successful aging in place.

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