A Seamless Value Co-Creation Service Roadmap of Assistive Technologies for The Elderly

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Abstract--Global population of the elderly is growing. Assistive Technologies (ATs), e.g. monitoring health & safety, information sharing & telecare, communication support, independent living and long-term care, can be an important enabler for the elderly care services responses to the elderly quality of life.

A service roadmap is an integrated technological service planning tool, focusing on the design of service system and emphasizing macro-level planning for a certain future period. Although essential technology roadmaps of ATs exist, there is little focus on service roadmap, which is necessary for elderly care service providers and stakeholders to propose appropriate value offerings in current and future market.

This study proposes the framework to promote the encapsulation of service-dominant logic (S-D logic) and open innovation into integrated service roadmap. Open innovation and S-D logic approach in roadmap facilitates value co-creation platform. Based on value co-creation concept, co-created values in service roadmap are proposed and value co-creation is embedded into service roadmap. The proposed seamless roadmap architecture is deployed for an Research and Development (R&D) firm as a case example. Multi-stakeholder, e.g. government, investors, social entrepreneurs/providers and innovation networks, firms may adopt this roadmap to their strategic planning and initiate the social innovation with impact.

I. INTRODUCTION

Aging is a global issue and quality of life of the elderly and the impact of the approaching to developing countries are in considering. Thailand first has been an "aged society" since 2005 [11] and will become a "complete aged society" in 2021 followed by a "super-aged society" in 2034 [12]. For the Association of Southeast Asian Nations (ASEAN), in 2015, there were three countries – Singapore, Thailand and Vietnam – in aged society. It is expected another five ASEAN member countries will become aged societies by 2025. In addition, by 2040, all ASEAN member countries will have aging society [3]. The number of the elderly people is growing, which raises the issues of elderly care services, medical care services, transportation services and etc. There are challenges and opportunities for the policy makers, researchers, technology and service providers and also the elderly and family. Thailand government concerns in this upcoming situation and has established 'integration plan' for creating equality and preparedness to aged society by value co-creation among all public-private stakeholders.

Information and communication technology (ICT) can play an important role in helping people to enhance the quality of life and well-being. Assistive technology (AT) is a domain of ICT that is specialized to help a person with disabilities and the elderly [20]. The research and development of new equipment, technology and service are need for the elderly.

On the other hand, firms have moved from manufacture sector to service sector as the global industry and business changed. Roadmapping needs to be fully integrated into a firm's strategic planning, corporate foresight [6], and business/service operation through integrated roadmaps for open innovation as a seamless value co-creation platform. Strategic thinking with S-D logic approach [14] which comprises of service ecosystems, collaboration, value proposing, designing and configuring can be fulfilled in integrated service roadmap.

In this paper, roadmapping, open innovation and S-D logic approach is employed to support the strategic planning of ATs for the elderly in research and development (R&D) firm. The research objectives are included in theoretical and practical aspects. Integrated service roadmap is employed in this study to analyse what services, products, technologies and research with open innovation and S-D logic approach is required to assist R&D firms in supporting the elderly in response to social needs and business & market drivers.

The key research questions are how can we 1) incorporate the open innovation approach into service roadmap; 2) use service roadmap effectively for open innovation contexts in R&D firms' strategic planning and service operation; and 3) apply S-D logic as a strategy into roadmap?

This study is organized as follows. First, in the section 'literature review' reviews the relevant studies and in the section 'methodology' explain our overall research design. The suggested service roadmap architecture and service roadmap in the context of open innovation and S-D logic is then proposed in the section 'case example'. The final section concludes the paper by discussing the limitations of our study and its implications for further research.

II. LITERATURE REVIEW

A. Technology roadmap

The term "technology roadmap" has gained widespread use in public, private, R&D, and academia. The term initiated by Motorola in the 1980s and focused on technologies for product development. In the 1990s, technology roadmap began to be applied to industry-wide R&D activities. At present, technology roadmap is adopted to internal corporate R&D initiatives and industry-wide R&D collaboration at the regional, national, and global levels. Technology roadmapping is gaining momentum as a strategic

management tool for a firm to integrate technology into business strategy [25] and changing business requirements [5].

Roadmapping is a powerful practical method that can help scientists and engineers to determine which technologies will use in the future so that they can contribute to solving the problem in society [20]. Roadmapping supports them to explore and communicate how their research can offer value. The roadmapping approach has been adopted by firms to support many different types of strategic aims, and term technology roadmapping can refer to many related techniques and approaches [19]. The most flexible and powerful framework for the development of roadmaps is represented schematically in Fig. 1, comprising a multilayers time-base chart, bringing together several perspectives into a single visual diagram. This type of roadmap enables both demand and supply side views to be represented, balancing market pull and technology push [16].

The generic form of roadmap illustrated the flexibility of the approach, which can be readily adapted to proper a wide range of goals and contexts. Roadmaps can be clustered into eight areas [18] based on structure and content which are project planning, capability planning, strategic planning, long-range planning, knowledge asset planning, programme planning, process planning and integration planning. The roadmap can provide a common reference point within the firm for supporting the dialogue need to achieve a greater degree of alignment [17].

B. Integrated roadmaps for strategic management and planning

Roadmapping is a complex long-term planning tool that allows for setting strategic goals and forecasting the potential of new technologies, products, and services. Roadmapping is used for strategic planning in both form of a technological and a market research perspective. Vishnevskiy [26] proposed an integrated roadmapping approach for the long run goal of social and economic development and bringing together the 'market pull' and 'technology push' approach.

The integrated roadmap includes four layers which are technologies, products, markets and alternatives.

There are research works on the development of an integrated product-service roadmap, An, Lee and Park [27] suggested integrated roadmap and roadmapping process that can help strategic planning and management of product-service. Daim [9] developed an integrated product-service roadmap, the 'service layer' has been introduced. Geum [28] suggested another type of technology roadmap; 'product-service integrated roadmap' by employing both 'product layer' and 'service layer' equally, using 'technology layer' as the main intermediate. It extends the study of technology roadmap from 'product-oriented' to 'product-service integrated' roadmap and also from manufacture sector to service sector. This product-service integrated roadmap can work more effectively in managerial practical context.

For the strategic planning in service sectors, technology roadmap can be a valuable tool to support strategic planning by integrating various planning elements such as product, service and technologies. Fig. 2 [1] shows basic formats of service roadmaps.

C. Open innovation and its process

Open innovation is defined as the use of purposive inflows and outflows of knowledge and technology to accelerate innovation [8]. The three core open innovation processes [4] are

1) the outside-in process - enriching a company's own knowledge base through the integration of suppliers, customers, and external knowledge sourcing can increase a company's innovativeness;

2) the inside-out process - the external exploitation of ideas in different markets, selling Intellectual Property (IP) and multiplying technology by channelling ideas to the external environment; and

3) the coupled process - linking outside-in and inside-out by working in alliances with complementary firms during which give and take are crucial for success.
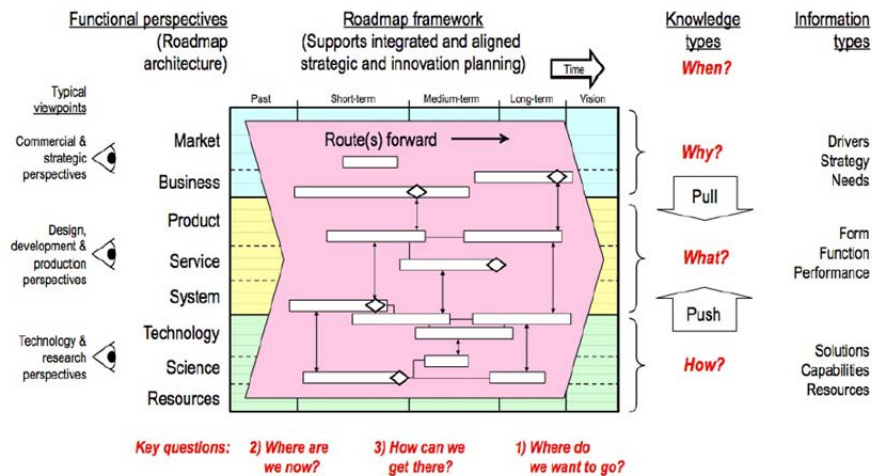

Figure 1 Generic form of roadmap [16]

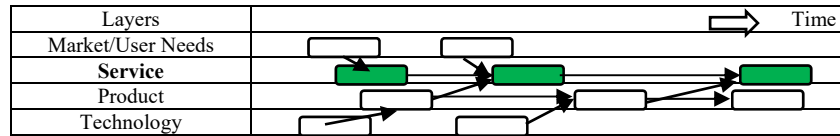| Layers						Time
Market/User Needs						
Service						
Product						
Technology						

Figure 2 the basic formats of service roadmaps

D. Structure and typology of technology roadmap for open innovation

Dual technology roadmap consists of five layers: market, product, technology, R&D, and partners [7]. A key factor in this dual technology roadmap is that it integrates the important characteristics of open innovation. Geum deployed two concepts of the technology roadmap with the duality of object and duality of the layer and suggested three types of outside-in innovation which are 1) purchasing, 2) in-sourcing, and 3) R&D collaboration for linking to technology roadmap. Inside-out Innovation is still not included in this study.

E. Service roadmap

Cho and Lee [2] defined technology roadmap developed for service sector planning as 'service roadmaps' to distinguish them from technology roadmaps in the manufacturing sectors. As service roadmap inherits the concept of technology roadmaps, service roadmap can be useful as a forecasting tool, a decision-making tool, and a communication and coordination tool. They suggested five types of service roadmap architectures which are 1) product-based service roadmap, 2) market-driven service roadmap, 3) service-technology roadmap, 4) technology-based service roadmap, and 5) product-service integrated roadmap. The structure of service roadmap varies by their purpose and with firm characteristics. For type 5) product-service integrated roadmap are primarily developed for planning mostly in the product-service organization: it uses expert opinion as the only input and has been applied to ICT human health and social work industries. Roadmapping should be carefully considered before roadmapping is conducted.

F. Service-dominant logic

As mentioned prior, firms have moved from manufacture sector to service sector as the global industry and business changed. Marketing inherited a model of exchange from 'good-dominant logic (G-D logic)', which based on based on the exchange of "goods" and usually are in manufacture sector. G-D logic focuses on tangible resources, embedded value, and transactions. The current perspective 'service-dominant logic (S-D logic)' has emerged that focused on intangible resources, the co-creation of value, and relationships [21]. Lusch and Nambisan [13] explained that S-D logic transcends the tangible–intangible and producer–consumer and also as the conceptualization of service innovation emphasized 1) innovation as a collaborative process through an actor-to-actor (A2A) network, 2) service as the application of specialized competences for the benefit of another actor or the self and as the basis of all exchange, 3)

the generativity unlocked by increasing resource liquefaction and resource density, and 4) resource integration as the way to innovate.

Lusch and Nambisan [13] offered a tripartite framework of service innovation: 1) service ecosystems, as emergent A2A structures actors create and recreate through their effectual actions and which offer an organizing logic for the actors to exchange service and co-create value; 2) service platforms, which enhance the efficiency and effectiveness of service exchange by liquefying resources and increasing resource density and serve as the venue for innovation; and 3) value co-creation, which views value as co-created by the service offeror (service provider) and the service beneficiary (service receiver) through resource integration and indicate the need for mechanisms to support the underlying roles and processes.

Regarding strategic thinking, S-D logic has the potential to provide increased firm viability, including increased profit. S-D logic is strategic, abductive and value creation process of the firm [14]. There are five ways in which S-D logic shapes the firm's strategic thinking which are 1) service ecosystems, 2) collaboration, 3) value proposing, 4) designing, and 5) configuring. The extension and update of S-D logic on axioms are updated by Vargo and Lusch which related to service and value co-creation, summarized in Table 1 [23].

TABLE 1 THE AXIOMS OF S-D LOGIC

Axiom	Description
Axiom 1/FP1	Service is the fundamental basis of exchange.
Axiom 2/FP6	Value is co-created by multiple actors, always including the beneficiary.
Axiom 3/FP9	All social and economic actors are resource integrators.
Axiom 4/FP10	Value is always uniquely and phenomenologically determined by the beneficiary.
Axiom 5/FP11	Value co-creation is coordinated through actor-generated institutions and institutional arrangement.

G. Roadmapping, S-D logic and Open innovation.

Firms may have a number of difficulties when without roadmapping or some other effective integrating approach e.g. [17]:

1) misalignment between different group, functions and levels within the organisation, and with customers, suppliers and partners
2) wasted resources and effort, and missed opportunities
3) being late (or early) to market
4) increased risk and a reduced awareness of risk
5) failure to exploit synergies within the business

TABLE 2 LITERATURE GAP AND RESEARCH OBJECTIVES.

Literature Gap	Research Objectives
1. Linking the new roadmap and existing business processes is essential to keep the roadmapping effort active.	1. How can we incorporate the open innovation approach into service roadmap?
2. Linking between roadmap and corporate strategic plan	
3. The method to select and customize the right roadmap process and architecture to meet a firm's objective.	2. How can we use service roadmap effectively for open innovation contexts in R&D firms' strategic planning and service operation?
4. The way to apply roadmapping to firm's service planning activities.	
5. The method to apply S-D logic as a strategy to service roadmap.	3. How can we apply S-D logic as a strategy into roadmap?

Roadmapping in service sectors can be challenging and by integrating of S-D logic and open innovation approach in term of value co-creation and resources integrator.

H. Literature Gap

Most research in the development of service roadmaps has been focused on the integration of technology/product/service roadmap and demonstration service roadmap through different cases. There have been some attempts discussing on open innovation approach for technology roadmap, however, few of them demonstrated the application of service roadmap for open innovation.

This paper presents a development route of 'technology roadmap, integrated roadmaps for strategic management and planning, service roadmap, technology roadmap for open innovation' towards 'service roadmap for open innovation and the adoption of S-D logic to roadmap'. The literature gaps and resulting research objectives are summarized in Table 2.

III. METHODOLOGY

We elaborate a methodology from both theoretical and practical perspectives. We analysed papers devoted to the technology roadmap, integrated roadmaps for strategic management and planning, service roadmap and technology roadmap for open innovation as mentioned in the section of literature review and papers concerning S-D logic [13], [22], [24]. The process of developing the roadmap includes four main phases:

A. Desk research

At this phase, all available and accessible codified knowledge and best practice in the correspondence fields are analysed. For this purpose, a literature review provides the generic service roadmap and open innovation is conducted.

B. Pre-roadmapping

During this phase, the research scope and key priority directions are defined. The needs, characteristics and benefits of the service roadmap of ATs for the elderly are explored through the multi-disciplinary expert interviews.

1) Interview structure
We applied 'semi-structured interview'. It was conducted in both of face to face interview and by a phone call.

2) Expert panel
This includes a combination series of expert interviews with representatives of 1) business firms, 2) R&D firm, 3) public firm and 4) academia. A list of experts is formulated during the previous stage and four selected experts are representative of key multi-stakeholders. Expert demographic profile is as below, categorised by area of expertise
  a) technology roadmap/technology foresight, executive from Thailand Center of Excellence for Life Sciences (TCELS) and ex-APEC technology foresight center
  b) innovation management, open innovation, service innovation and service science, academia from faculty of business administration, Dhurakij Pundit university
  c) The older persons, Strategic planning, Executive, Expert from Department of Older Persons, Ministry of social development and human security.
  d) assistive technology/the disable and older persons, executive/expert from National Electronics and Computer Technology Center (NECTEC)

3) Interview questions issues.
The key questions are
  a) Challenges & opportunities for creating service roadmap to assistive technology for the elderly.
  b) How can we incorporate the open innovation into technology/service roadmap?
  c) How can we use technology/service roadmap effectively in firm's strategic planning for different social innovation & open innovation contexts?

4) Expert's interview results.
As mentioned in 2) Expert panel, there are four experts from multi-disciplinary areas. Thailand, at present, is preparing for upcoming aged society. The government has integration plan on policy and budget. There are eight ministries which work on Aged society and the Elderly. They are working on 'the elderly' agenda-based. For the policy integration, the expected output is the service system of social-economics, health and environment for the elderly. The outcome is the elderly can access to above-mentioned services and the impact is the elderly has quality and secure of life. The government is now focusing on the development of technology and innovation of long term care service. Three of four experts on the panel are involved in the government policy-budget integration plan as innovation project proposer and focal

point of the project. For 'service roadmap of assistive technology for the elderly', they have a common opinion that it is good challenges and opportunities for the synergies power from public-private sector and R&D and service sectors to move forward on the elderly matter. There are actions and a clear vision from a government site. There are R&D institutes, universities and service providers which need an actor to actor collaboration and integrated resources as S-D logic and also open innovation approach for R&D collaboration. The outcomes are the appropriate services which response to needs of the elderly and the capability of service & technology providers and also the challenges for social entrepreneurs. Especially for R&D firms which want to shift from R&D based to service based. It can adapt the service roadmap with S-D logic and open innovation approach as one of the strategic planning tools.

C. Roadmapping

Referring to the past studies of the evolution of technology roadmap, open innovation and service roadmap development included the conceptualization of S-D logic; we encapsulate S-D logic into service roadmap. The key S-D strategies focus which adapted to our roadmap is 1) increasing the effectiveness of the firm's roles as an integrator of resources and a co-creator of value through service exchange, 2) value creation involves the integration of multiple resources by multiple actors simultaneously or as part of an integrative process 3) operant resources (knowledge and skills, competencies) are perceived as having

agency and thus as capable of influencing their environment, and 4) innovation requires both innovation agency and the continual monitoring of practices and their contexts [14]. For the foundation, the value co-creation is spread over the roadmap. The seamless value co-creation roadmap is explained with the sequence of architecture and relationships as below.

1) Architecture

The key factor in our proposed service roadmap is it integrates the important characteristics of open innovation and S-D logic. Fig. 3 illustrates our suggested seamless value co-creation service roadmap, which consists of seven layers: market/user needs, service, product, technology, R&D, knowledge and partners. The first characteristic of the seamless value co-creation service roadmap is the encapsulation of S-D logic concept into a service layer, so the roadmap employs the value co-creation between service providers and service receivers. The roadmap can be realized by the addition of the service layer. The second characteristic is the use the 'partner layer' as the originality of collaboration among stakeholder and represents integrator of resources.

Fig. 3 illustrates the flows of technology-product-service development which responses to market as servitization

2) Service Roadmap for open innovation

Fig. 4 shows the three types of service roadmap for open innovation especially for outside-in open innovation which is 1) purchasing, 2) in-sourcing and 3) R&D collaboration.
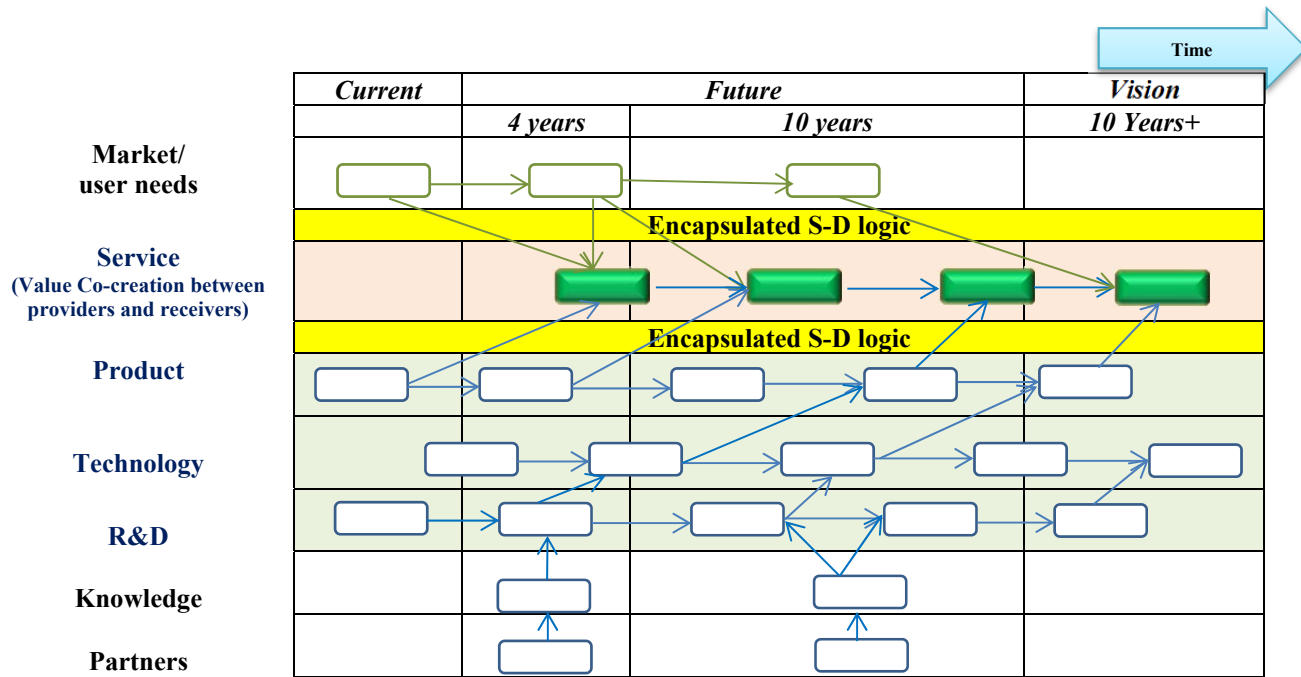

Figure 3 Architecture of proposed value co-creation service roadmap (adapted from [7], [2])

Service		
Product		
Technology	Internal	
	External	
R&D		
Knowledge		
Partner		

(a) Purchasing

Service		
Product	Internal	
	External	
Technology	Internal	
	External	
R&D		
Knowledge		
Partner		

(b) In-sourcing

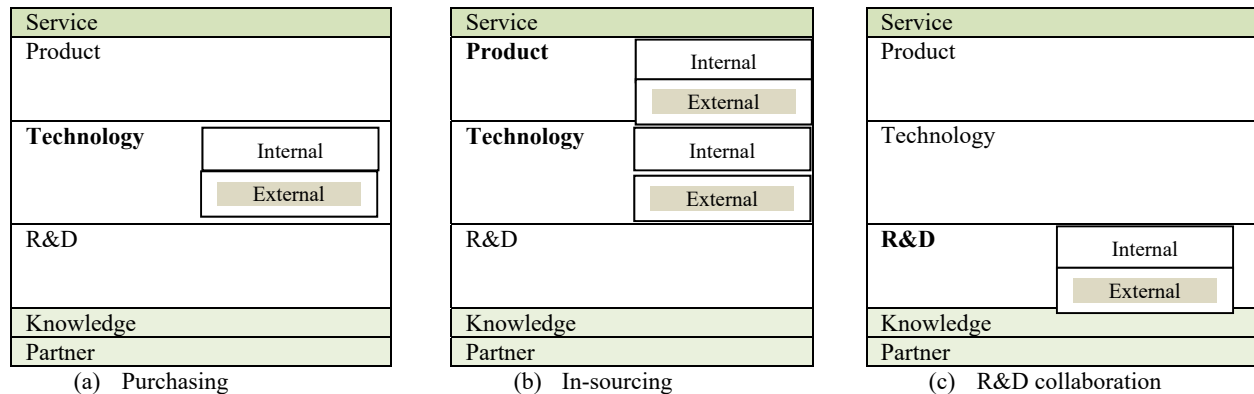| Service		
Product		
Technology		
R&D	Internal	
	External	
Knowledge		
Partner		

(c) R&D collaboration

Figure 4 Architecture of proposed service roadmap for open innovation (adapted from [7])

3) Service roadmap based on value co-creation concept

One of the outcomes of the seamless value co-creation service roadmap is enabling firms to forecast the future directions of possible roadmap results and their relevance to multi-stakeholders or actors in addition to direct service receivers. Fig. 5 illustrates the value co-creation and relationships in service roadmap.

There are five main roadmap stakeholders:

1. government could use the results of service roadmap to forecast the direction of technology and innovation development and respective policy making;
2. investors and social entrepreneurs can use service roadmap as a tool to make the decision for investing;
3. innovation producers and service providers can use service roadmap as a tool to plan their business process and to produce products and provide service that will be in response to demand in the future;
4. innovation networks which are R&D firms, universities, technology professional associations can develop their R&D programs based on service roadmap to proper to needed research and also prepare to shift from R&D based to service based in the future, if need.
5. The elderly, family, caregiver are key receivers or beneficiaries can receive the proper services and have the well-being life.

The co-created value in service roadmap creates by a collaboration of stakeholders (providers and receivers) to support the service roadmapping. Co-created values in the service roadmap include 1) firm strategic planning, 2) entrepreneurial opportunity, service quality and accessibility and 3) the elderly's well-being, quality of life and life confidence.

D. Data Validation

We increased the validity of findings by incorporating finding from member check with four experts.

There are five items which is asked for checking from experts in respective of their expertise.

1) interview results
2) architecture of proposed service roadmap on value co-creation and open innovation
3) co-created value in service roadmap
4) case example of R&D firm's service roadmap of assistive technology for the elderly

These items were agreed and confirmed.

IV. CASE EXAMPLE

To illustrate the applicability of our proposed service roadmap, we examine case example with a governmental R&D firm. Please be noted that the development of this service roadmap tool in this paper is based on this firm's previous Technology roadmap and a strategic map. In a practice, a service roadmap should be developed among stakeholders and experts. The detail of this R&D firm is as below.

1) Firm background

This case example is one of the laboratories in a governmental R&D firm, Thailand, which specialises in rehabilitation engineering and assistive technology. This firm is now preparing to spin-off from the government sector and become a public organisation.

2) The firm's objective and motivation in applying service roadmap approach

The firm's objectives are to a) promote R&D for disabled and the elderly for aged society and towards to commercialise value-added product, b) provide academic, consultancy, universal design, training and project management, c) promote and support the new industry/service for aged society, d) create collaboration network among user and provider (public and private) for resources sharing and e) recommend policy on public service infrastructure towards the quality of life of a person with disabilities and the elderly

Government

Macro-level policy and plan

Prospective research areas

Investors/Social entrepreneurs

Technology-market specifications

Investment in new technologies and services, supply the demand of market segments

Matching industry development, industry priorities, foster strategy decisions

Technical-economic expertise and assistant, financial support

Co-created value: firm strategic planning

Producers/Providers

Demand on R&D, market research and evolution, production plan

Innovation network

R&D plans, collaboration network build-up

R&D technology transfer and commercialization and anticipated demand

R&D implementation plans, emerging technology deployments, local R&D investment, and collaboration network build-up

Co-created value: entrepreneurial opportunity, service quality and accessibility

Receivers/beneficiaries (the elderly, family, caregiver)

Co-created value: well-being, quality of life, life confidence
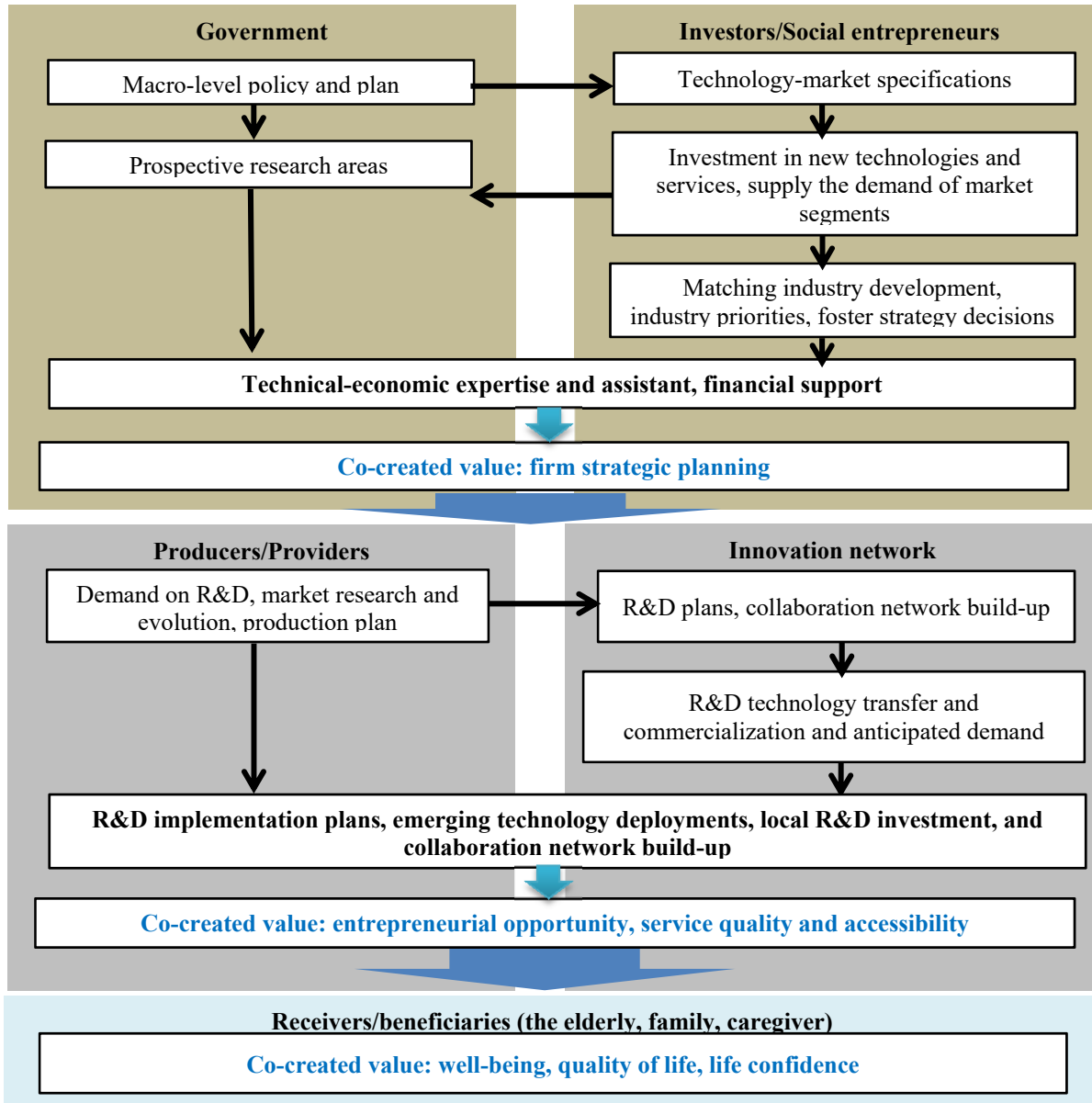
Figure 5 Value co-creation in service roadmap (adapted from [26])

4) R&D firm's service roadmap of ATs for the elderly

The case example deals with R&D firm on rehabilitation, assistive technology and ICT which actively conducts R&D and implement products as well as closely collaborate with public and private firms on the elderly and person with disabilities. This R&D firm is aiming to shift from R&D based to service based in the upcoming future.

Fig 6 shows the finalized suggested service roadmap. The roadmap shows firm's R&D capabilities towards technology, product and proposed services which response to needs from the market and social drivers. This initial service roadmap represents the current and forward steps of the firm for linking and delivering products/services to social and industry.

5) R&D firm's service roadmap for open innovation

Fig. 7 represents 'R&D collaboration' in service roadmap. There are both of the internal and external R&D entities are involved in R&D collaboration. In this case example, National Metal and Materials Technology Center (MTEC) and Sirindhorn National Medical Rehabilitation Institute (SNMRI) have R&D collaboration to develop 'artificial knee implant'.

V. DISCUSSION

Our research findings suggest the proposed service roadmap that can be used for integrated planning for R&D firms which plan to shift from research-based to service-based; whereas it also can be adopted in a service organization as a tool for technology-based service planning. Service roadmap is incorporating with open innovation and S-D logic then firms can use this roadmap as strategic planning and service operation. We clarify the incorporation by these three applications.

A. Roadmap beneficiaries

The main roadmap beneficiaries/stakeholders/actors are 1) R&D institute as roadmap owner, 2) institute which want to do integrated research-product and service offering that deliver value in use, 3) government policy regulator and promoter, 4) manufacturers of innovation products/services, 5) investors and social entrepreneurs, 6) innovation networks, and 7) the elderly, parents and caregivers.

B. Service roadmap for open innovation and its utilization

Referring to Fig.4 architecture of proposed service roadmap for open innovation, the open innovation approach (outside-in and inside-out innovation) as a seamless tool is adapted to R&D collaboration among multi-stakeholders. Firms need to plan their open innovation from future-oriented perspective. Regarding this approach, the firm needs to know which 'Partner' and which 'R&D' based on product and/or technology are collaborated as a co-created value and finish with offering 'service'.

C. S-D logic as strategy in service roadmap

S-D logic has the potential to provide increased firm viability, including increased profits and the additional insights into what actors can do to shape their destiny [14]. We apply S-D logic as a strategy on 1) the increasing of the effectiveness of the firm's roles as an integrator of resources and a co-creator of value through service exchange in dynamic systems and 2) value creation involves the integration of multiple resources by multiple actors simultaneously or as part of an integrative process.

The value co-creation process among actors is bundled through the encapsulation of S-D logic into service roadmap. This seamless value co-creation service roadmap does not act only as 'visual communication diagram' but also raise multi-collaboration among actors. From S-D logic view, this service roadmap acts as 'A2A collaboration' and also as 'service platform' to create emergent values by bundling different type of co-created value propositions.

S-D logic strategy creatively developing firm and guiding the development of ecosystem and possibilities of what will happen in future with the process of value creation under the S-D strategy.

For this case example, this roadmap can be one of the stepping stones of R&D firm which planning to spin off from government sector to public organization and also shift from research-based to service-based firm.

R&D Firm's Service Roadmap of Assistive Technology for The Elderly

Category			2016-2019	2020-2024	2025-2029	2030+
Driver			Aged society	Complete aged society		Super-Aged society
			Aging Preparedness	Universal Design (UD) & Assistive Technology (AT)		
			Public-Private Partnership & Business Opportunities for SMEs			
			STI Commercialization			
Market/User Needs			Physical safety	Aged in Place & Long-Term Care		
			Social Participation			
			Well-Being & Quality of Life & Life Confidence			
Service	Universal Design		Accessibility	Health Information System		
			Home Based Monitoring			
	Assistive Technology		Speaking Aid	Closed Captioning	Telelcom Relay	
Product	Universal Design		ICT Accessibility	Transportation & Mobility		
	Communication		Telelcom Relay			
			Closed Captioning			
	Education & Learning		Blended Learning Management System			
	Daily life		Exercise equipment	The Elderly home		
	Medical & Rehab		Artificial knee implant	The elderly health information system		
			Smart Bed	Hearing Aid	Cognitive Rehab	
Technology	Universal Design		UD Barcode	WCAG		
			Screen reader			
	Learning & Education		e-PUB			
	Independent living		Exercise equipment	Aged friendly environment		
	Medical & Rehab		Hearing Impairment	Visual Impairment	Physical Impairment	
Knowledge and R&D	Rehabilitation Technology		Rehab Medicine	Physical therapy	Occupational therapy	
			Speech Pathologist	Rehab Engineering		
	Assistive Technology		Speech Technology	Material Science		
	Information and Communication Technology		Computer Science	Telecommunication	Hardware Design	
			Digitized Content	Software Engineering	Circuit design	
			Embedded System	Computer Network	Pattern Recognition	Sensor
Partners	Government		NBTC MoSDHS MoE	DLT DOP MoPH	SNMRI	
	R&D Firm		MTEC NECTEC			
	Private Company		Anonymous			
	Independent agency		NHSO Thaihealth			
	NGO/Social Entrepreneur		ThaiNetizen			

Figure 6 R&D firm's service roadmap of assistive technology for the elderly

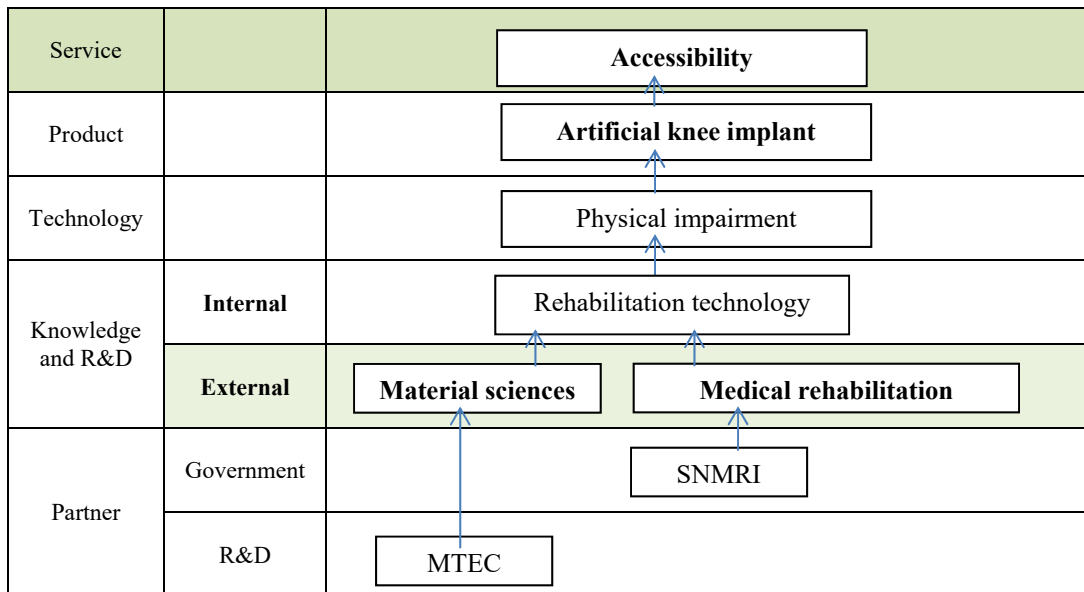| Service			Accessibility	
Product			Artificial knee implant	
Technology			Physical impairment	
Knowledge and R&D	Internal		Rehabilitation technology	
	External	Material sciences		Medical rehabilitation
Partner	Government		SNMRI	
	R&D	MTEC		

Figure 7 R&D collaboration in service roadmap for open innovation

VI. CONCLUSION

This study proposes the value co-creation service roadmap framework to promote the encapsulation of S-D logic and open innovation into R&D Firm's service roadmap. The roadmap is not limited only to communicating strategies but also to identifying resources required to enter new business areas [10].

This roadmap can be one of the stepping stones for
1) R&D firms, which plan to shift from research-based to service-based,
2) Multi-stakeholders, who may adopt this roadmap to their strategic planning and initiate the social innovation with impact, and
3) Social entrepreneurs, who can use the roadmap to see opportunities to innovate new services with co-created value among multi-stakeholders.

This roadmap can strengthen the open collaboration among multi-stakeholders which potentially support the advancement of social, economic and technological influences on services for Thailand's upcoming aging society.

This study is subject to some limitations. First, we conducted semi-structured interviews with four experts and have no session for reviewing the roadmap architecture design. Future research should conduct pre- and post-roadmapping workshop for more debating and evaluating the roadmap architecture. The roadmapping workshops/process serves as a mechanism to bring actors/stakeholders together in a workshop, shaping their decision and coordinating their actions to achieve an agreed vision of the future [15].

Second, in the case example, we use secondary data from firm's profile and do prototyping initial service roadmap. Future studies should conduct roadmapping workshop in practice with all stakeholders in each roadmap layer as full case studies that encompass the entire planning process.

Third, regarding open innovation development, the illustrations of outside-in open innovation are
1) Bringing ideas to market (lab to market),
2) Out-licensing and or selling IP (intellectual property and technology licensing), and
3) Covering spin-off.

Fourth, the application of S-D logic to service roadmap in this study is only limited to 'value co-creation' but 'service ecosystem' and 'service platform' [13] also can be adapted to service roadmap. Firms need to evolve S-D logic for strategic planning and move forward to servitization.

Finally, the recommendation to the roadmapping of this seamless value co-creation service roadmap is the roadmap needs to be reviewed and updated as the service's environment and technology change.

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