Leveraging Digital Health Platforms in Developing Countries: The Role of Boundary Resources

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Abstract. The pervasiveness of digital platforms has resulted in the emergence of digital health platforms addressing various health care needs globally. Digital platforms, typically, bring about an international division of labor between platform owners in developed countries where they are usually developed and platform consumers in developing countries leveraging them. In this relationship, boundary resources, such as documentation and application programming interfaces, are critical elements in the efforts to leverage digital health platforms in developing countries. This paper uses the case of the digital health platform DHIS2 in Malawi to elucidate and discuss the enabling and restricting roles played by boundary resources towards efforts leveraging digital health platforms in developing countries.

Keywords: Digital Platforms, Digital Health Platforms, Boundary Resources, Developing Countries.

1 Introduction

In the advent of platformization (Helmond, 2015; Nieborg and Poell, 2018), digital platforms are permeating into different spheres of modern life. Social media platforms such as WhatsApp, Instagram, Twitter and Facebook have transformed people's modes of interaction and sharing experiences. Mobile operating system platforms like Android and iOS have transformed the computing industry leading to an era of computing on the go. In the same vein, mobile payment platforms such as mPesa and Airtel Money are disrupting the financial industry in sub-Saharan Africa. Similarly, digital platforms at the heart of the sharing economy, such as Uber and Airbnb have, respectively, transformed the age-old transportation and hotel industries. Consequently, digital platforms have become an omnipresent research phenomena in the information systems (IS) landscape (de Reuver et al., 2018).

The term platform is used in diverse ways (Gawer, 2009) and platforms can be digital or non-digital (de Reuver et al., 2018). Nevertheless, Baldwin and Woodard (2009), define platforms as modular systems comprising of a set of stable core components and a complementary set of variable peripheral components. Gawer (2009) further elaborates this perspective by stating that all platforms, digital and non-digital, share the same fundamental architecture comprising of a set of core components with low variety and a complementary set of peripheral components with high variety, and taken together the low variety components are what constitutes the platform.

From this underlying perspective of a platform emerges the common understanding of what constitutes a digital platform. In line with this perspective, Tiwana et al. (2010) and later on Tiwana (2013) define a software platform as an extensible software-based system comprising of components and interfaces that work together to provide core functionality shared by complementary applications (or *"apps"* for short) that interoperate with it through the said interfaces. Therefore, a software platform serves as a foundation on which outside parties, other than the platform owner, can build derivative and complementary products or services that often come in shape of applications.

An application, in this context, is an add-on software subsystem that connects to the software platform to extend its functionality (Tiwana, 2013). Software platforms and their complementary applications are key elements of software ecosystems. A software ecosystem consists of a software platform, a set of complementary applications, a set of internal and external developers, a community of domain experts, and community of end-users whose needs are met by composing the software platform and application specific to it (Bosch and Bosch-Sijtsema, 2010).

The pervasiveness of digital platforms has led to software ecosystems emerging as a dominant model for software development (Tiwana et al., 2010) and just like in other industries, digital platforms built for various purposes are emerging in health care (de Reuver et al., 2018), giving rise to what have been labelled *digital health platforms* or *e-health platforms* (Vassilakopoulou et al., 2017). As a result of this global trend, some existing e-health applications commonly used in developing countries, for example the District Health Information Software version 2 (DHIS2), have been subjects of platformization which has turned them from mere applications to digital platforms (Msiska, 2018; Polak, 2015). Leveraging (i.e., taking advantage of) existing digital health platforms such as DHIS2 affords developing countries the opportunity to save on the cost, time and effort required to implement e-health solutions.

Digital platforms fundamentally change the international division of labour by creating a new model of collaboration between developed and developing countries (Tatsumoto et al., 2009). A majority of contemporary digital platforms originate (or are developed) in developed countries and subsequently appropriated for use in developing countries. This potentially shifts the construction of finished products from platform owners in developed countries to platform consumers in developing countries (Tatsumoto et al., 2009). A similar observation is made by Dittrich (2014) who labels platforms as "half-products" because they defer part of the effort required to compose a finished product to actors in the context where they are actually used.

While digital platforms come with the opportunity to build applications on top of them, local innovation does not come by itself. Boundary resources (Ghazawneh and Henfridsson, 2013, 2010), have been identified as critical elements to innovations on top of digital platforms (de Reuver et al., 2018). This paper based on the case of the DHIS2 software platform in Malawi, a developing country in sub-Saharan Africa, explores the role of boundary resources in efforts leveraging digital health platforms in developing countries. In line with this, the paper addresses the question *in what ways do boundary resources facilitate the leveraging of digital health platforms in developing countries*? The rest of the paper contextualizes boundary resources in the frame of

generative collectives, presents the methodology used and the case, and winds up with a discussion and a few concluding remarks.

2 Generative Collectives and Boundary Resources

Notably, platform-centric software ecosystems are associated with a collective of human actors that includes, among others, platform owners, third-party developers, and end-users. In line with this observation, Osch and Avital (2010) define *generative collectives* as groups of people with shared interests whose mutual rejuvenating, reconfiguring, reframing, and revolutionizing acts drive creativity and innovation. The potential of such collective to generate innovations, with respect to the software platform, is referred to as *collective generative capacity* (*ibid.*).

Such collective capacity stems, in part, from the generative capacities of individuals making up the collective. In this respect, *generative capacity* denotes an individual's ability to produce something in a particular task-driven context (Avital and Te'eni, 2009). In other words, generative capacity is a person's ability to engage in acts that lead to innovation or production of value in a given context (Osch and Avital, 2010). With respect to a software platform, generative capacity can be used to denote the ability of an individual to leverage the platform as a basis for constructing applications as derivative innovations.

Hierarchically, Osch and Avital (2010) observe that collectives encompass a small esoteric community and a larger exoteric community, each consisting members of the collective sharing certain traits and interests. With respect to software ecosystems, the internal esoteric community is represented by the platform owners and the external exoteric community is represented by platform consumers at large. Implicitly, these two communities are separated by a boundary. Boundaries are a separation of two groups of people arising from differences in interests and identity (Wenger, 2000). Boundaries, typically, constitute channels through which competences, experiences and resources are exchanged resulting in enrichment of generative capacities on either side. The ensuing exchange, according to Wenger (2000), is facilitated by three bridges: *boundary objects*, *boundary interactions*, and *brokers*, as described in the table 1 below.

Table 1. Boundary Bridges

1.	**Boundary Objects:** artefacts, including tools and documents for example, that link or are shared by communities across a boundary
2.	**Boundary Interactions:** events or encounters, for example visits and meetings, that provide direct exposure to members of another community
3.	**Brokers:** human actors operating between communities and engaged in the import and export of competences, knowledge and resources

Since software platforms represent a division of labour between platform owners and platform consumers (Tatsumoto et al., 2009), they also necessitate the shifting of generative capacity between the two communities (Prügl and Schreier, 2006; von

Hippel and Katz, 2002). Therefore, the bridges between communities within a software ecosystem as a collective – boundary objects, boundary interactions and brokers – can be instrumental in deriving insights with respect to this shift and help shape our understanding of potential implications for leveraging digital health platforms in developing countries.

In relation to this, Ghazawneh and Henfridsson (2010) define *boundary resources* as software tools and regulations, such as application programming interfaces (APIs) and software development kits (SDKs), that facilitate an arms' length relationships between platform owners and external actors leveraging software platforms to create derivative innovations. Through boundary resources platform owners allow external actors to exploit the platform to meet their needs (Karhu et al., 2018). In agreement with this, Eaton et al. (2015) observe that software ecosystems constitute distributed actors collectively leveraging boundary resources in their efforts to extract value from an underlying software platform. Therefore, boundary resources have the potential to play a significant role towards the leveraging of digital health platforms in developing countries.

3 Methodology

Empirical data on which this paper is based came from a case study (Myers, 1997; Walsham, 1995) focusing on efforts in Malawi leveraging the DHIS2 software platform carried out between 2015 and 2017. DHIS2 is a digital health platform developed under the Health Information System Programme at University of Oslo (HISP UiO) in Norway. HISP is a global action research project (Braa et al., 2004) made up of national and regional nodes across the world. Besides HISP UiO, other nodes in the project include HISP India, HISP South Africa, HISP Tanzania, HISP Malawi, HISP East Africa and HISP West Africa to name just a few.

Action research is a collaborative research where the researcher joins research subjects in efforts aimed at solving a problematic situation and conducts research while effecting change (Cornford and Smithson, 2005). In this respect, the overarching aim of HISP is to strengthen health information systems in developing countries by using a participatory development approach (University of Oslo, 2016). As part of HISP efforts in Malawi various interventions are being undertaken to strengthen the national health management information system leveraging DHIS2 as the underlying digital health platform.

The case study employed a qualitative approach anchored by an interpretivist paradigm (Orlikowski and Baroudi, 1991; Walliman, 2011). In interpretive case studies, data is usually collected through interviews complemented by observations, document reviews and web-based data sources such as emails, mailing lists and websites (Creswell, 2009; Myers, 1997; Walsham, 2006). In this particular case study, empirical data was collected using interviews, participant observations, document reviews and web-based data sources.

Interviews involved staff from different stakeholder organizations involved in the efforts leveraging DHIS2 in Malawi. The key stakeholder organization around DHIS2

in Malawi is the Central Monitoring and Evaluation Division (CMED) under the country's Ministry of Health (MoH). Stakeholder organizations collaborating with CMED in this endeavor include, among others, HISP Malawi, Baobab Health Trust (BHT), University of Malawi, International Training and Education Center for Health (I-TECH), Luke International – Norway (LIN) and D-Tree International. Respondents for interviews were purposefully sampled (Creswell, 2009) from these stakeholder organizations depending on their involvement with respect to the efforts leveraging DHIS2 in Malawi. Altogether, 25 respondents drawn from these organizations were interviewed.

Further data was collected through participant observations carried out with respect to various DHIS2 related interventions in Malawi. Such interventions included, for example, the DHIS2 reconfiguration and data migration project that was carried out between August 2015 and May 2017, the DHIS2 web applications development workshop in March 2016, the DHIS2 android applications development workshop in October 2017 and the mHealth4Afrika application development project between January 2015 and December 2017. Complementing interviews and participant observations, data was also collected using document reviews and web-based data sources such as the DHIS2 Malawi mailing list and websites for HISP UiO, HISP Malawi and MoH.

Data analysis in the study involved an iterative review of textual representations, for example transcripts and fieldnotes, of data collected. Thematic analysis (Braun and Clarke, 2006; Maguire and Delahunt, 2017; Vaismoradi et al., 2013) which involves assigning *codes* to segments of textual data as means to identify *themes* which would form the basis of interpretation (Walliman, 2011) was employed as an analytical technique during the study. The outcome of this process was a corresponding coding structure from which interpretations could be elicited.

4 DHIS2 in Malawi

Efforts to leverage the DHIS2 digital health platform in Malawi commenced in 2009 as a pilot project in three districts: Blantyre, Zomba and Lilongwe. After three years of intermittent piloting, DHIS2 was rolled out to all the 28 districts of Malawi in 2012. As part of efforts to leverage the DHIS2 digital health platform in Malawi several key activities have been undertaken. These include, among others, deployment and regular updates of DHIS2 instances, creating custom data entry forms to preserve familiarity in transition from paper-based forms and development of new applications not readily available as part of the DHIS2 bundle. In these activities actors in Malawi have been interfacing with HISP UiO as the platform owner through various boundary resources. Such boundary resources are not limited to Malawi alone but other countries that form DHIS2 platform consumer community. At this point we use a frame composed of boundary objects, boundary interactions and brokers to highlight the various boundary resources we identified.

4.1 DHIS2 Boundary Objects

In the DHIS2 ecosystem there exists different boundary objects that external actors in Malawi and other countries interface with. First among these are DHIS2 manuals. With each version of DHIS2, HISP UiO releases an end-user manual, an implementers manual and a developer manual to convey requisite knowledge to enable respective human actors leverage the platform. While the manuals are pivotal in global efforts leveraging DHIS2, the case in Malawi shows that, sometimes they are "*a source of problems if they are out of sync with their corresponding version*" [HISP Malawi, Technical Assistant].

Besides manuals, other key boundary objects, include APIs, an Android SDK, D2 Libraries, DHIS2 app stores and code repositories that enable development and distribution of apps by external actors. The state of these boundary resources determines their usability or readiness for use. For example, the Android SDK is, largely, still work in progress which means currently there is limited support for Android application development within the DHIS2 ecosystem except through the available APIs.

4.2 DHIS2 Boundary Interactions

While leveraging the DHIS2 platform, actors in Malawi have had a wide range of boundary encounters with HISP UiO representatives. As a common tradition within the DHIS2 ecosystem, such boundary interactions include DHIS2 academies and workshops. DHIS2 academies are training events held within countries at both national and regional levels attracting participants from both the hosting country and other countries leveraging DHIS2.

In Malawi, boundary encounters have also involved various academic exchanges between the University of Oslo and institutions in Malawi. As part of efforts to leverage DHIS2 in Malawi, several PhD and masters students from Malawi have been trained at University of Oslo granting them an exposure to DHIS2 and bringing them into the HISP fold. These students have been critical in establishing a collective of expertise to support CMED and other stakeholders around DHIS2 in Malawi.

At the same time, several PhD students and master's students from University of Oslo have undertaken various assignments around DHIS2 in Malawi. In addition to these, HISP UiO is offering internships to app developers from Malawi and Mozambique through a new agreement involving the University of Oslo (Norway), the University of Malawi (Malawi) and Eduardo Mondlane University (Mozambique). All these boundary encounters have been essential conduits for various expertise required to leverage DHIS2 in Malawi, and similarly other countries.

4.3 DHIS2 Brokers

In addition to boundary objects and interactions earlier described, different human actors are deployed to serve as brokers of requisite capacity between HISP UiO and actors in Malawi and other countries leveraging DHIS2. Predominantly, these include facilitators of DHIS2 academies and workshops. Apart from academy and workshop

facilitators, researchers, including PhD and master's students, at different times serve as brokers between HISP UiO and actors in developing countries leveraging DHIS2. Occasionally, this role has been undertaken by consultants engaged by HISP UiO or its collaborating partners.

These human resources crisscrossing the boundary between HISP UiO and stakeholders in Malawi play an essential role in mitigating capacity gaps and propagating requisite competences for DHIS2 in Malawi and, similarly, in other countries that are currently leveraging the platform. While endeavoring to establish adequate local expertise, CMED and stakeholders in Malawi, have intermittently been reliant on the boundary human resources engaged by HISP UiO. Through them there has been an import and export of knowledge, resources and competences related to DHIS2 between HISP UiO and stakeholders in Malawi.

5 Discussion

Taking examples from the case of DHIS2 in Malawi, described in section 4 above, Table 2 below categorizes boundary resources according to their underlying role within the software ecosystem. In this regard, boundary resources either serve as means of building requisite capacity for leveraging the digital platform or means for developing complementary applications on top of the digital platform. This enables a demarcation between *capacity building boundary resources* and *software development boundary resources*. Drawing on the work of Ghazawneh and Henfriddson (2013) we propose an extended boundary resources model that captures both capacity building and software development boundary resources as illustrated below.

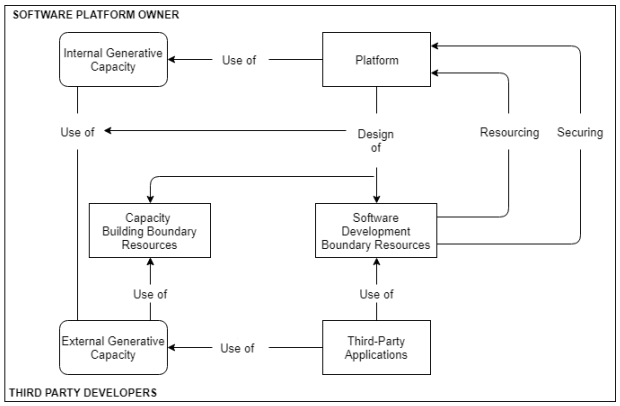

Figure 1 Extended Boundary Resources Model

Table 2. Summary of Boundary Resources in DHIS2 Ecosystem and Their Roles

Resource	Form	Role	Resource Category
DHIS2 Academy or Workshop	Boundary Interactions	Capacity Building	Capacity Building Boundary Resources

DHIS2 Manuals	Boundary Objects	Capacity Building	Capacity Building Boundary Resources
Academy/Workshop Facilitators	Brokers	Capacity Building	Capacity Building Boundary Resources
DHIS2 APIs, Libraries and SDKs	Boundary Objects	Facilitating App Development	Software Development Boundary Resources

In this respect, software development boundary resources comprise of boundary objects, such as SDKs and APIs, that regulate and facilitate development of complementary applications on top of a digital platform (Ghazawneh and Henfridsson, 2013; Msiska, 2018). Capacity building boundary resources, on the other hand, comprise of boundary objects, boundary interactions and brokers deployed within a platform's ecosystem to facilitate propagation of generative capacity between platform owners and platform consumers at large. The implicit capacity shift that digital platforms introduce between platform owners and platform consumers (Prügl and Schreier, 2006; von Hippel and Katz, 2002) necessitates the existence of both software development boundary resources and capacity building boundary resources.

For developing countries, capacity building boundary resources are necessary to overcome age-old human capacity challenges which have been the cause of failure and unsustainability of health information systems in such countries (Kimaro and Nhampossa, 2005). Therefore, to enable developing countries effectively leverage digital health platforms, software development boundary resources must be accompanied with appropriate capacity building boundary resources to facilitate the propagation of requisite human capacities.

For digital health platforms in developing countries, boundary resources serve as agents of technology appropriation – the taking of a piece of technology and making it one's own (Draxler and Stevens, 2011). Drawing on the work of Ghazawneh and Henfriddson (2013), we suggest a platform appropriation model, depicted in figure 2. The model illustrates the complementary roles played by software development and capacity building boundary resources in relation to the appropriation of digital health platforms, and digital platforms in general, by platform consumers in developing countries. Applications required within context of use cannot be developed without relevant application development capacity. In addition to application development capacity, requisite capacities for leveraging digital health platforms also include: deployment capacity, customization capacity, usage capacity and system administration capacity (Msiska and Nielsen, 2017). Hence, capacity building boundary resources play an essential role as conduits of these requisite capacities without which it would be difficult for developing countries to leverage digital health platforms despite the promises they hold.

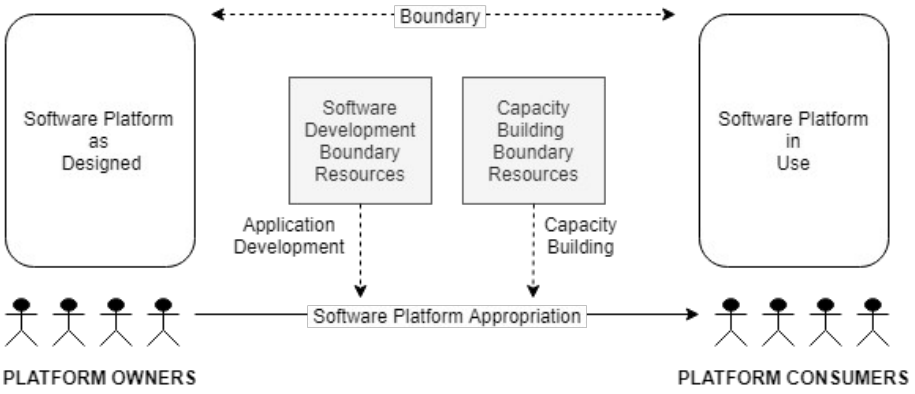

Figure 2. Software Platform Appropriation Model

Depending on their state boundary resources can act both as enablers or constraints towards appropriation of digital platforms in developing countries. In agreement with this, Ghazawneh and Henfriddson (2013) use the terms *resourcing* and *securing* to reflect the enabling and restricting roles of boundary resources. The extent to which developing countries can leverage digital health platforms hinges on the range of capacity building and software development boundary resources that come with such platforms.

6 Conclusion

The pervasiveness of digital platforms has seen them permeating several industries across the globe, including the healthcare industry. This has given rise to digital health platforms addressing different health concerns in both developed and developing countries. Digital platforms bring about an international division of labor between platform owners and platform consumers. In leveraging such platforms, boundary resources play a critical role. In this respect, using the case of DHIS2 in Malawi, this paper demarcates between software development and capacity building boundary resources which collectively aid the appropriation of digital health platforms in developing countries like Malawi.

Because of the inherent division of labour that comes with digital platforms, both capacity building and software development boundary resources are equally important. If any of these boundary resources are lacking it would be challenging for developing countries to take full advantage of the platforms despite the promises they hold. Consequently, the state of boundary resources provided can either enable or restrict various efforts in leveraging digital health platforms in developing countries. Therefore, platform owners must pay attention not only to the platform features but also the capacity building and software development boundary resources associated with the platform.

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