digital impact alliance

spotlight

Can we future-proof Digital Public Goods?

Rethinking sustainable business models

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Key Insights

1. **Sustainability is paramount when Digital Public Goods (DPGs) are deployed to create the digital public infrastructure** that enables the effective provision of essential society-wide functions and services.

2. **DPGs must learn from, and collaborate with the global open source software community** which has vast experience in building communities and creating public goods like Linux, Apache and others.

3. **The DPG ecosystem has missing institutions** like foundations and Commercial Open Source Software (COSS) companies that can accelerate the growth of DPGs.

4. **Inter-governmental collaboration around DPGs can help reduce global government spending** on procurement of software, which grew by 12% to reach $151.8 billion in 2022.

5. **Grant money should be used as seed capital for building DPGs, and the open source community around DPGs.** Sufficient capital should be allocated for evangelizing, selling and deploying the DPGs to ensure widespread adoption.

6. **DPG funding is a marathon, not a sprint.** Therefore, it may be necessary to build new programs, and a new cadre of funders who have the appetite for long-term funding.

SECTION 1

Introduction

Digital Public Goods in Context

A recent report from the UN Secretary General titled, "Roadmap for Digital Cooperation," focused its spotlight on the emerging field of Digital Public Goods (DPGs). In its section on "Building an Inclusive Digital Economy and Society," the report noted, "Digital public goods are essential in unlocking the full potential of digital technologies and data to attain the Sustainable Development Goals, in particular for low- and middle-income countries."

DPGs are defined as, "open-source software, open data, open AI models, open standards, and open content that adhere to privacy and other applicable laws and best practices, do no harm by design, and help attain the Sustainable Development Goals (SDGs)."[1] For the purpose of this paper, we will focus on DPGs as open source software, since this is a defining characteristic currently driving much of the interest in and deployment of DPGs.

The use of DPGs for building national Digital Public Infrastructure (DPI) for delivering citizen services is taking off. For example, the Modular Open Source Identity Project (MOSIP) hosted at the Indian Institute of Information Technology, Bangalore (IIITB) is being used to provide Digital IDs in Philippines, Togo and Morocco, and being piloted in Guinea, Ethiopia, Sri Lanka and Sierra Leone.[2] Discussions with multilateral agencies and funders indicate that over 40 countries are in various stages of evaluating and implementing DPI.[3]

While DPIs can be implemented using DPG or proprietary software, for the purpose of this paper, we will focus on DPGs because they have the potential to enable funders and developers to build once but deploy many times, owing to the highly replicable nature of software programs released under open source licenses. DPGs are also increasingly attractive to policymakers seeking mechanisms to establish some level of digital sovereignty. As multilateral agencies and funders converge on these opportunities, added attention must be paid to the sustainability of DPGs. Of course, sustainability models have relevance for DPGs broadly, but this issue is of critical importance when DPGs are deployed as an input into foundational digital infrastructure (e.g. identity, payments, and data exchange).

The Intent of the Paper

The lifecycle of Digital Public Goods consist broadly of four stages -- Create, Deploy, Sustain and Evolve. Current funding models for DPGs focus primarily on the first two stages. This paper applies the lens of an open source practitioner to look at funding models that support all four stages, and is aimed at DPG funders and developers.

DPGs have a lot to learn from the success of Open Source Software (OSS) in all four stages. For example, Linux, the most successful OSS of all time, started off as a student project and has grown into an operating system that has 27.8 million lines of code,[4] has been deployed on everything from supercomputers to the Mars Rover, to smartphones to embedded computers. Linux is sustained by a vibrant ecosystem of companies like Red Hat, Canonical and many other organizations that provide services and support around it. The Linux code base is also constantly evolving with new players like Huawei, and former opponents like Microsoft actively contributing to the code.[5]

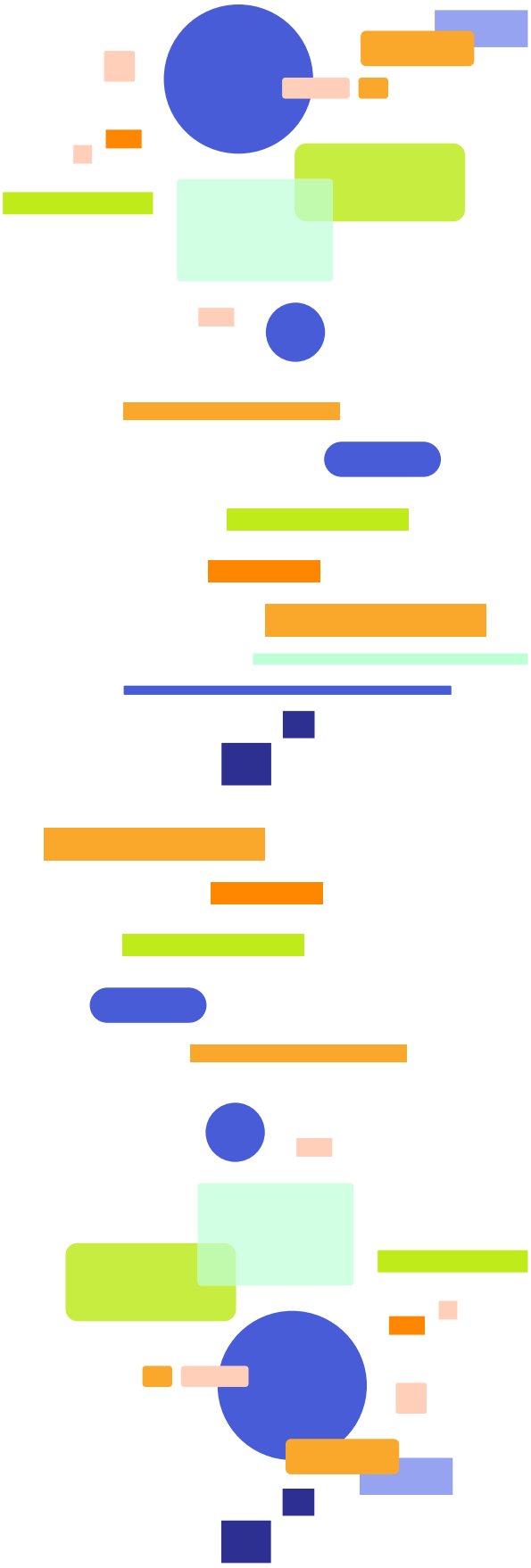
15 years ago, proprietary software with restrictive licensing norms and controlled by individual vendors was the norm while open source software (OSS) released under liberal open source licenses and developed by communities of volunteers distributed around the world, was the exception. Today, OSS has become the "new normal" because the power of Collaborative Innovation (enabled by open source licenses and Internet based collaborative development tools) leads to rapid development of infrastructure components. This can be seen in the fact that most emerging technologies like big data and analytics, blockchain and others are now dominated by OSS.

The growth of OSS has led to competitors working together on open source projects at the infrastructure layer, while competing with each other at the customer facing application layers. Companies now actively encourage their employees to contribute to OSS projects[6] because it helps them shape the direction of technology, improves the skills of employees, impresses customers and potential hires, and helps organizations track the latest innovations.[7]

DPGs open up similar possibilities of inter-governmental collaboration around developing OSS for governments. To that end, this paper explores the following hypotheses:

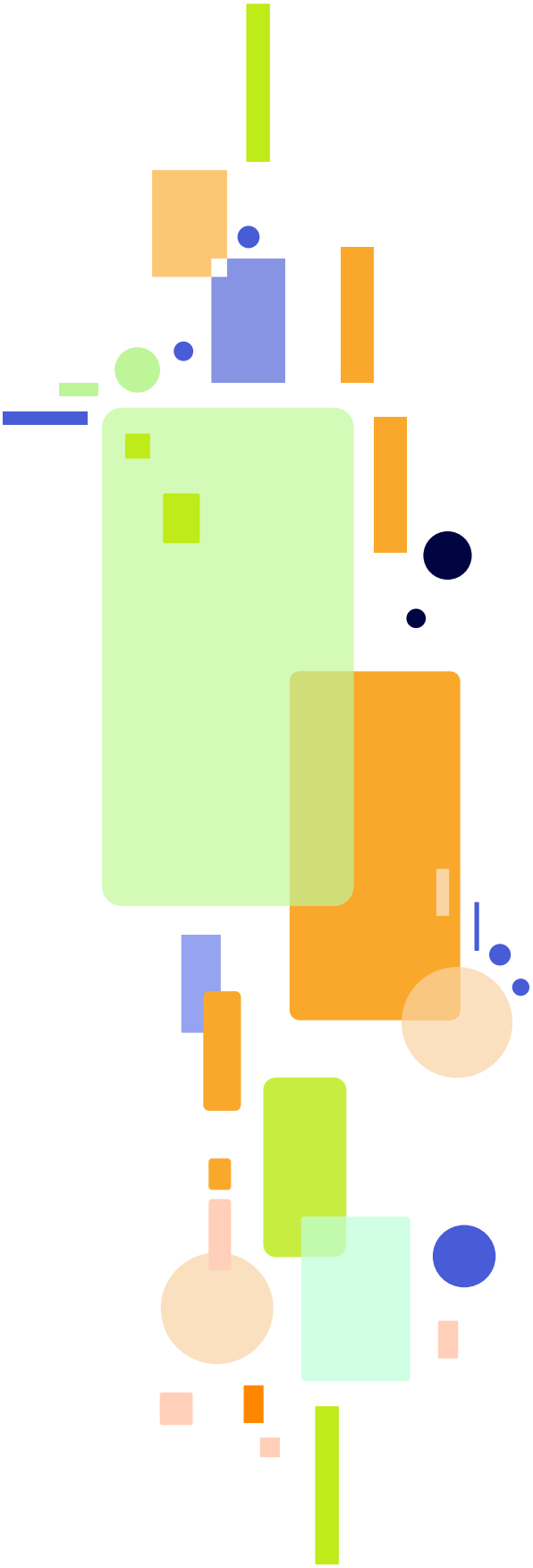
1. Grant money should be used as seed capital for building DPGs, and the open source community around DPGs
2. Sufficient capital should be allocated for evangelizing, selling and deploying the DPGs to ensure widespread adoption
3. A vibrant ecosystem of System Integrators (SIs) should be built around DPGs. SIs should be incentivized to deploy DPGs and also evolve the DPG code base
4. DPGs can become the basis for inter-governmental collaboration for building, maintaining and deploying open source software.

In this framing, each part of the ecosystem feeds into the other, creating a virtuous cycle that becomes self-sustaining over time.



SECTION 2

Building Sustainable DPGs



A Holistic Approach

A sustainable DPG requires support across all four stages of the DPG lifecycle—**Create, Deploy, Sustain and Evolve.** This document looks at each stage, explores alternatives to the current thinking and provides suggestions on how the DPG ecosystem can be made more sustainable.

Create

Some DPGs like the Modular Open Source Identity Project (MOSIP) and MojaLoop have been funded by grants while others like OpenCRVS and DHIS2 started as grassroots open source projects. MOSIP has benefited from almost $50 million in funding while MojaLoop received $25 million in funding. In contrast to MOSIP and MojaLoop, OpenCRVS started as a bootstrapped project, while DHIS2 started as project supporting the decentralisation and integration of the health services post-apartheid in South Africa.[8] DHIS2 is now used as a health management information system (HMIS) in **73 low and middle-income countries.** Approximately 2.4 billion people live in countries where DHIS2 is used. Including NGO-based programs, DHIS2 is in use in more than 100 countries.[9]

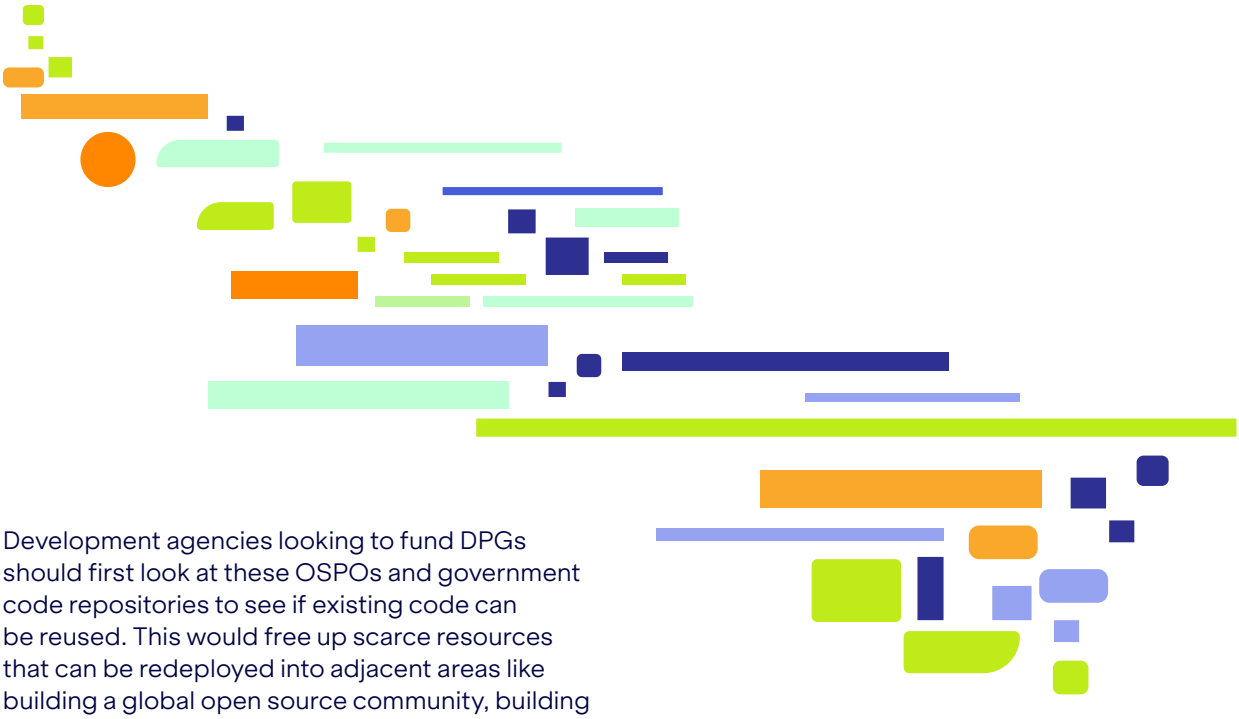
DHIS2 development has roots in post-apartheid South Africa. DHIS, the predecessor to web-based version DHIS2, sprang from a collaboration between South African public health activists and Scandinavian-based information system developers and eventually led to the development of DHIS2 in the mid-2000's. DHIS2 is currently supported by Norad, the **Research Council of Norway**, **PEPFAR**, and **The Global Fund**.[10]

Table 1. Government IT Spending Forecast by Segment, 2021–2022, Worldwide (Millions of U.S. Dollars)

	2021		2022	
SEGMENT	SPENDING	GROWTH (%)	SPENDING	GROWTH (%)
IT SERVICES	188,069	10.9	203,922	8.4
SOFTWARE	135,630	14.9	151,885	12.0
TELECOM SERVICES	61,482	1.4	60,996	-0.8
INTERNAL SERVICES	64,245	0.3	65,971	2.7
DEVICES	41,049	17.6	40,390	-1.6
DATA CENTER	32,735	6.5	34,154	4.3
TOTAL	523,212	9.5	557,318	6.5

Source: Gartner (August 2021)

While various DPG funding models have emerged, government spending remains relatively untapped. As a sector, governments are the biggest spenders on IT. Gartner estimates that government procurement of IT services grew by 8.4% to reach $203.9 billion, while procurement of software grew by 12% to reach $151.8 billion in 2022 (Table 1). As the DHIS2 example shows, software is a reusable commodity with DHIS2 software used across 100 countries. Can reusable open source software (OSS) be used to reduce the $151.8 billion spent on government procurement of software? With growing awareness of open source, governments are setting up Open Source Program Offices (OSPOs) to support the usage and creation of OSS. More and more governments are also hosting their code on public repositories. For example, the US Government hosts its code on GitHub while the Indian Government hosts its code on OpenForge. These OSPOs and code repositories can be leveraged by the DPG movement to identify software that can be globally relevant DPGs. Over the next few years, DPGs have the potential to be an important catalyst in a global collaborative movement that helps governments bring down software procurement costs significantly.



Development agencies looking to fund DPGs should first look at these OSPOs and government code repositories to see if existing code can be reused. This would free up scarce resources that can be redeployed into adjacent areas like building a global open source community, building a vibrant system integrator ecosystem etc that may be outside the remit of these repositories. In areas like payments, where some countries have built successful solutions, development agencies could use their influence to have these solutions open sourced as DPGs.

Closer collaborations among local and global open source developers and governments can also help in the creation of DPGs. The Covid-19 websites and contact tracing apps built by volunteer developers are one such example.

CREATION MODEL	DPGS
Intentional funding and creation of DPGs by development agencies	MOSIP, MojaLoop
Grassroots, bootstrapped DPGs	OpenCRVS, DHIS2
Co-creation with local open source developers	Covid-19 website, contact tracing apps
Closed source to Open Source, unlocked by using influence of development agencies	India's Unified Payment Interface (UPI)[11]

Deploy

A DPG becomes the core of a Digital Public Infrastructure (DPI) when it is deployed and starts getting used by citizens. While DPI can be implemented using closed source software, for the purpose of this discussion paper, we confine ourselves to DPIs built using DPGs.

A vibrant ecosystem of System Integrators (SIs) is essential for implementing DPGs. At a bare minimum, countries need at least three SIs to bid for a Request for Proposal (RFP) for implementing DPGs. If not, the RFP processes usually get restarted, leading to loss of time and effort. In the transformation of a DPG into a DPI, SIs play a vital role. Without a vibrant ecosystem of SIs, investments in creating DPGs risk becoming a dead loss. This section looks at how DPG deployments can be made sustainable.

- **Demand Aggregation:** SIs are "follow-the-money" actors who respond to demand. A viable pool of DPG implementation opportunities is therefore essential to create a vibrant ecosystem of SIs. One way of thinking about SIs is as a film set that is erected upon demand. When a confirmed business opportunity is in hand, SIs hire and deploy the technical and project management talent at their disposal. Having hired expensive resources, and gained hand-on experience through one deployment, most SIs would like to leverage this further through similar business opportunities. Therefore, for SIs to survive and thrive, they need a pipeline of near-term and long-term business opportunities.

  The DPG ecosystem has to find ways and means of nurturing SIs for DPGs, and could take lessons from software giants like Microsoft, Red Hat and others who have decades of experience running SI programs. Mature DPGs like the e-Gov Foundation's DIGIT software for Urban and Local bodies (ULBs) have reached a stage where ULBs specifically demand DIGIT implementations and a robust set of SIs cater to this demand across India. This is an ideal situation where DPG demand and supply are evenly matched. In this regard, solutions like the MOSIP Marketplace[12] and the DIAL Catalog are steps in the right direction.[13]

- **Project Management:** At the country level, the project leaders who implement DPGs have to have the ability to evaluate the vendors, project manage the selected SIs and ensure a smooth handover of the project. Deployments need to factor in the available state capacity of each country and bolster the project management and technical capacities as required.

- **Funding:** From a funding perspective, DPG deployments are funded by countries through their own resources, or with support from bilateral or multilateral agencies. At this stage Requests for Proposals (RFPs) are drawn up and bids invited from SIs. A key requirement at this stage is to ensure a large number of high quality bids that enable implementation agencies to discover the best capabilities and prices. RFP processes of most governments were designed for an earlier era of physical infrastructure and need updating to be suitable for digital infrastructure. Complicated RFPs and their requirements (for example, that bidders need to have turnover above a particular number) usually end up excluding smaller bidders who don't have the turnover specified, or the capability to engage in a long RFP process. DPG RFP processes should be reworked to allow a larger number of SIs to participate in the bid process. This will encourage competition and grow the DPG SI community.

- **Simplifying DPG Deployments:** DPGs can also be made easier to try out, configure and deploy so that the cost of deployments can be brought down. Sandboxes and experience centers where countries can evaluate the DPG prior to implementation, can help cut down the time to implementation. Cloud based deployments of DPGs could be considered in countries that have reliable bandwidth. Smaller countries who do not have the critical mass could consider co-hosted servers in other countries. To protect their digital autonomy, these servers could be treated like embassies that have special privileges in the host state, such as immunity from most local laws. Estonia has pioneered this approach by setting up a Data Embassy in Luxembourg that is fully under the control of Estonia.[14]

In sum, making DPGs easy to deploy, creating commercial incentives that enable a vibrant ecosystem of SIs and making the RFP process easier for participating companies can accelerate the deployment of DPGs.

Sustain

For countries that are considering implementing DPGs, especially in core DPI like identity, payments and data exchange, sustainability of the project is essential. Will the DPG be around for the next five years? Will there be organizations who support the DPG, provide security updates, customization and updates well into the future? In building DPGs, the creation and deployment phases have received a lot of attention but the next two phases of sustaining and evolving the DPG have not received enough attention. The experiences of the global open source community may be instructive in this regard.

- **Developer Community:** In the open source community, when evaluating two competing software, users prefer the software that meets their needs best and has the most vibrant developer community.[15] The number of developers actively contributing code, the ratings and stars received by the project, and the liveliness of the discussion forums are all indicators of a vibrant community that can sustain an open source project into the future.[16] At this point in time, there are very few DPGs that have a robust open source community around them, possibly because of pressure from funders and government agencies to focus on time-to-deploy. This creates a Catch-22 situation where developers stay away from contributing voluntary time to a DPG because they know that a commercial service provider is being paid to do the work.

  This is a situation where the old African proverb truly applies. "If you want to go fast, go alone. If you want to go far, go together." Building and nurturing an open source community may be more time consuming initially, but is much more sustainable in the long run. DPGs are not general purpose software programs like Linux, that can attract a broad base of software developers. However, DPGs can serve as a platform for a global, intergovernmental collaborative effort that creates open source software for the public good. Some early evidence can be seen from the fact that the Ethiopian Government agency implementing the Modular Open Source Identity Project (MOSIP) is now contributing to its code base, as are some of the System Integrators working with MOSIP.

- **Funding:** Sustainability should be one of the cornerstones of funding, especially for the core DPGs. Once implemented, core DPGs like identity, payments and data exchange become the foundation upon which a host of other digital infrastructures are built. Understandably, governments and SIs would like to know how sustainable the funding for the DPGs are before they invest in them. For example, for most of its 17 year history, the e-Gov Foundation benefited from long-term support from the Nilekani Philanthropies, with Tata Trust, Omidyar and others coming in much later.The result of such sustained long-term funding is that Urban and Local Bodies now recognize e-Gov Foundation's DIGIT as a trusted software system and seek to implement it. In turn, this demand has created a robust ecosystem of System Integrators who implement DIGIT. In contrast to Nilekani Philanthropies, most funders do not have the appetite for such funding time horizons and typically have budgeting cycles that are barely long enough to support the "Create" and "Deploy" phases of DPGs.. Therefore, it may be necessary to build new programs, and a new cadre of funders who have the appetite for long-term funding. In other words, DPG funding is a marathon, not a sprint.

- **Successful Deployments:** As the old adage goes, "Nothing succeeds like success." Successful implementation of DPGs go a long way in giving confidence to other users who are evaluating the same DPG. On the other hand, a botched DPG implementation could scare users away from deploying the DPG. Therefore, the DPG ecosystem would do well to take a leaf out of the playbook of Commercial Software Vendors (CSVs) who spare no effort to ensure that the first few deployments of their software succeed.

When introducing a new product, CSVs identify "Early Adopter" organizations who are well respected in their sector, and build these implementations as "lighthouse" case studies. Since these early adopters are taking a risk in using unproven software, CSVs will often subsidize the implementation and provide the same free or at cost. The quid pro quo is that these Early Adopters agree to highly visible implementations and speak about the CSV implementation at customer forums.

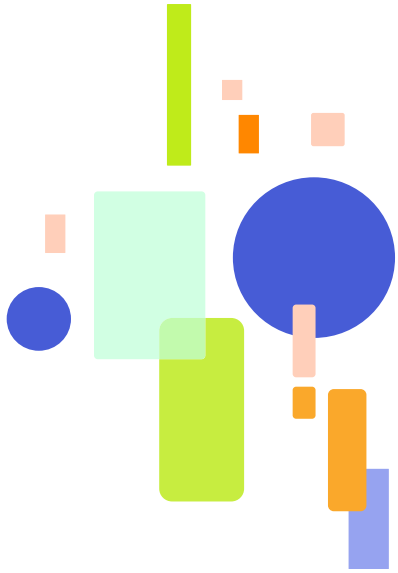
To de-risk the early implementations, CSVs often fund capacity building within selected SIs. This ensures that, when a project materializes, SIs have the necessary implementation capabilities. In a similar vein, DPGs and their funders could financially support the first few implementations. This has the dual benefit of increasing the chances of successful deployments and building implementation capacity within the ecosystem. This approach has higher up front costs, but will help create a robust ecosystem in the long run. For example, when an RFP for implementing a DPG is released, this approach can help ensure that the minimum three bidders are ready to bid for the DPG implementation. This base of SIs who have the skill sets and capability to implement DPGs will go a long way in building confidence among countries implementing DPGs.

Evolve

Open Source projects measure the health of a project[17] through metrics like the number of contributors, number of bug reports filed, positive/negative mentions on social media, shares, likes and subscriptions on social media, the social reach of contributors, number of organizations using the project, number of maintainers, percentage change of code over time, how welcoming and diverse the project is, and other measures.

For DPGs too, a vibrant community of developers is vital to ensure continued evolution and innovation, well into the future. Anecdotal evidence from MOSIP and the e-Gov Foundation indicates that organizations implementing the DPGs are willing to contribute code back to the DPG. For example, Viraj Tyagi, CEO of the e-Gov Foundation mentioned in a podcast[18] TransServ and IDFC Infrastructure integrated a GIS module with e-Gov's DIGIT software's tax assessment module to do property assessments and contributed that code to the DIGIT platform. Bharat Electronics Limited, a large Indian government owned SI also contributed a few new modules to DIGIT. In the case of MOSIP, the Ethiopian Government agency that is implementing MOSIP has contributed a few modules and has expressed strong support for open source, and willingness to contribute to its code base.[19]

DPGs have the potential to serve as a Government to Government (G2G) collaboration platform and significantly reduce government software acquisition and implementation costs. As this early evidence points, SIs involved in the DPG ecosystem can also play a part in sustaining and evolving the code base. As a DPG becomes more accepted and demanded by governments, SIs contributing to its code base can gain a competitive edge over those who don't. Some DPGs like MojaLoop also provide nudges by listing only those SIs who contribute to their code base on their website. DPGs would also do well to join and benefit from projects like CHAOSS, an open source project at the Linux Foundation focused on creating analytics and metrics to help define community health. In sum, funders and DPG developers must prioritize hiring community managers and building an open source community, sooner rather than later in the life cycle of a DPG.

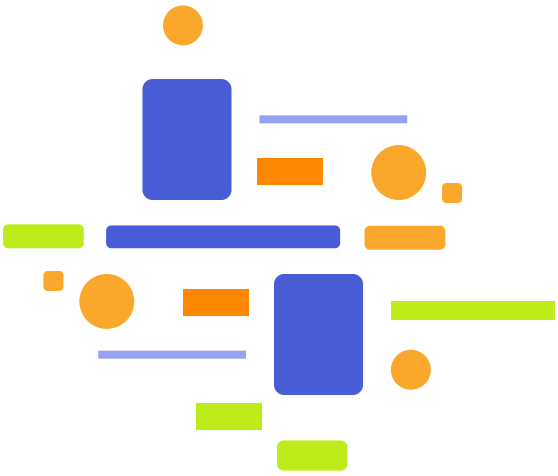


SECTION 3

Looking Forward

New Technologies, New Approaches

Across the world, countries have differing levels of state and market capacity and therefore require different approaches tailored to local conditions. For DPG deployments in countries with small populations and low state and market capacity, cloud based deployments might be easier. In cases where countries have populations that are in the 100,000s, a shared services cloud deployment might make sense. To ensure digital sovereignty, the co-located servers can be treated like embassies in a foreign country. Cloud computing offers a faster path to deployment and lower cost of operations, but requires countries to have reliable bandwidth for it to be effective.



For large DPG deployments in countries with large populations but low state and market capabilities, a technology transfer arrangement where the SI builds the project and hands over parts of development and maintenance of the project to a local vendor, might work best. This might also need to be mandated in the procurement contract to ensure development of local capabilities, and reduce dependence on external vendors.

New technologies also offer radical new possibilities. For example, when it comes to identity systems, countries are spending millions of dollars to build digital ID systems. A rough thumb rule is that it costs approximately $2 to provide an ID to an individual and therefore the cost of a national ID system is the population of a country, multiplied by two. Since Digital IDs are more akin to public goods, the private sector is reluctant to create them, except in very limited circumstances because of the difficulty in monetizing them. The responsibility of providing Digital ID therefore falls on governments, which may not always have the state capacity to deliver these IDs.

In such a scenario, an emerging technology like Web 3.0 could provide an alternative. A decentralized but highly interoperable identity network can be created to onboard individuals. Organizations that onboard individuals onto the Digital ID (DID) platform could charge individuals for onboarding and/or get incentives everytime the DID is used. This provides the private sector with incentives to onboard individuals onto a DID platform. A system of reputation management can be created to incentivise good behavior, dis-incentivise bad behavior and keep the IDs current and usable by other players like financial service providers, healthcare providers and other users. A part of the revenues from the DID network could go to a treasury. Members could vote and allocate

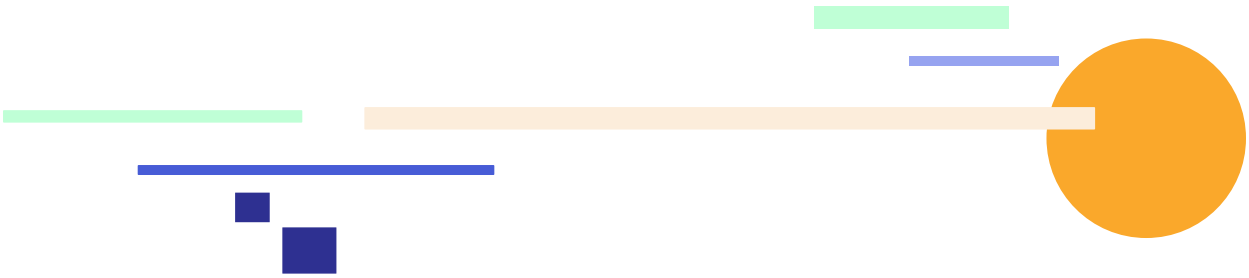
treasury resources to tasks like creating security patches, upgrades and updates that keep the system up-to-date. Consent based mechanisms could ensure privacy protection by giving users control of their data, and allowing them to easily issue/revoke consent to other parties.
Such a system could potentially require much lower startup capital than a big-bang, central government led DID deployment. Capital from funding agencies could be used as seed capital to set up the DID platform, and usage fees could be used to expand, sustain and evolve the network. Web 3.0 could allow for coordination of contributions and governance by distributed stakeholders. These are early days for these technologies and much work needs to be done to think through the governance models and system design. However, if harnessed well, Web 3.0 could help us build sustainable DPGs.

DPG funders and developers can also take a page from the open source community to evaluate whether there are missing institutions in the ecosystem. Open Source foundations like the Linux Foundation and the Apache Foundation have successfully incubated hundreds of OSS projects. The Linux Foundation hosts 1.15 billion lines of code, and estimates that the total shared value created by the Linux Foundation community is around $54.1 billion. The foundation hosts over 750 OSS projects and provides governance structure and back-end resources to all projects.[20] It also has business support programs that let developers scale awareness and project adoption. This frees up developers to focus on software development. The Foundation generated around $177 million in revenue from four main sources, Memberships and Donations, Project Support, Training and Certifications, and Event Registration and Sponsorship. The Apache Foundation hosts 350+ open source projects and initiatives, and estimates that its projects manage 271M+ lines of code worth $22 billion.[21] The foundation generates revenues of $3 million through sponsorships, events and donations.[22] The DPG ecosystem could replicate this model to accelerate the growth of DPGs and collaborate with existing Open Source Foundations to adopt their best practices.

Another path that can be explored is setting up for-profit entities on the lines of Commercial Open Source Software (COSS) companies. COSS firms like Red Hat, EnterpriseDB and others make it easy for organizations to adopt OSS by providing 24/7 support, patches and upgrades and other services that an organization needs. COSS firms take a popular OSS project and build a sales and support engine around it. In other words, open source projects typically focus on the development of the software, while COSS firms work with System Integrators, hardware vendors, Independent Software Vendors to build an ecosystem, and sell their software to governments, enterprises and others. Today, most DPGs do development, sales/country adoption, ecosystem development and support themselves. This places huge demands on the small teams managing these DPGs.

In the COSS approach, the DPG projects can be funded to develop the software, while COSS DPG companies take the responsibility of sales, support and ecosystem development. These companies would be able to offer market linked salaries and retain talent through stock options, while the ability to offer sales incentives to its teams could accelerate deployment. If the market size supports it, each DPG could have multiple COSS companies around it to spur competition. COSS firms could also raise venture capital on their own to scale up the business. However, such an approach will have to be carefully calibrated so that it is in alignment with the social objectives of DPGs.

In sum, Web 3.0, and setting up of foundations and COSS firms for DPGs could help us reimagine the DPG lifecycle, and this is an area that needs more research in future.



SECTION 4

Conclusion

Building sustainable DPGs requires a holistic view that encompasses each stage of its lifecycle. In core areas like identity, payments and data exchange, the sustainability of the DPG becomes a critical parameter for countries, as these DPGs serve as foundational layers of their Digital Public Infrastructure. Currently, funding for DPGs go to the Create and Deploy stages, which leads countries and SIs to wonder what would happen if the funding runs out.

A robust open source community built around each DPG would give greater confidence to countries and SIs evaluating the DPG, and helps the DPGs navigate the Sustain and Evolve phases well. Ensuring that the early deployments are successful gives countries and SIs greater confidence in investing in a DPG. Building a global inter-governmental community around DPGs will help countries reduce the $151.8 billion spent on software procurement annually. Creating “missing institutions” like foundations that can incubate DPGs and COSS firms that can build the ecosystem, and provide sales and services can help accelerate the growth of the DPG ecosystem. In the future, Web 3.0 could help us create frameworks that encompass the entire lifecycle of a DPG -- from Create, Deploy, Sustain to Evolve. The success of the OSS community holds many lessons that can help DPGs become self-sustaining over a period of time.

Endnotes

1 See the Digital Public Goods Alliance webpage at https://digitalpublicgoods.net/digital-public-goods/

2 *See Maturing MOSIP enjoys ID4Africa limelight as it expands its partnerships and vendors flock* at https://www.biometricupdate.com/202206/maturing-mosip-enjoys-id4africa-limelight-as-it-expands-its-partnerships-and-vendors-flock

3 Author's interviews with funders and multilateral agencies.

4 See *Linux 5.12 Coming In At Around 28.8 Million Lines, AMDGPU Driver Closing In On 3 Million* at https://www.phoronix.com/scan.php?page=news_item&px=Linux-5.12-rc1-Code-Size

5 See *Statistics from the 5.10 kernel development cycle* at https://lwn.net/Articles/839772/

6 See *The Top 10 Companies Contributing to Open Source* at https://www.mend.io/resources/blog/the-top-10-companies-contributing-to-open-source/

7 See *Why your company should contribute to open source* at https://opensource.com/business/13/2/why-company-contribute-open-source

8 See *HISP History* at https://www.mn.uio.no/hisp/english/about/history/index.html

9 See *About DHIS2* at https://dhis2.org/about/

10 See *Developing Nations Improving Health Communication Through the Use of DHIS2 (Part 1)* at https://www.openhealthnews.com/articles/2017/developing-nations-improving-health-communication-through-use-dhis2-part-1

11 Unified Payment Interface is housed within India's National Payment Corporation of India (NPCI) which runs the payments backbone of India as Digital Public Infrastructure (DPI). Its success as an instantaneous bank-to-bank transfer mechanism over mobile phones has prompted interest from other countries in implementing it. However, the UPI code is not open source. Therefore, multilateral agencies are requesting the Indian Government and NPCI to open source the code. The success of Aadhaar, India's digital biometric ID, prompted similar requests for the code and technology from other countries. Challenges in open sourcing Aadhaar, which is housed inside the government run Unique ID Authority of India (UIDAI) led to the creation of the Modular Open Source Identity Project (MOSIP), an open source DPG that is being implemented in Morocco, Philippines and piloted in a few other countries. One key lesson from this experience is that it is hard to extract source code out of an institution, once it is established and operating a DPI. Therefore, the ideal path is to keep the ownership of the technology protocols and code housed within a non-profit, which takes care of its technical evolution and maintenance, while its implementation as DPI can be housed within for-profit or non-profit operating entities. This allows the technical specifications and the DPI to evolve independent of each other. In other words, DPGs and DPIs should be unbundled from each other.

12 See *MOSIP Marketplace* at www.marketplace.mosip.io

13 See *DIAL Catalog* at https://solutions.dial.community/

14 See *Estonia's Data Embassy* page at https://e-estonia.com/solutions/e-governance/data-embassy/

15 See *6 reasons this nonprofit chose Backdrop for its open source CMS* at https://opensource.com/article/22/4/backdrop-cms

16 See *Top tips for selecting open source software* at http://oss-watch.ac.uk/resources/tips

17 See *How to measure the health of an open source community* at https://opensource.com/article/19/8/measure-project

18 See *Transforming governance with Open Source platforms with Viraj Tyagi | Episode 16* at https://buildforbharat.podbean.com/e/transforming-governance-with-open-source-platforms-with-viraj-tyagi-episode-16/

19 Author's interview with Yodahe Zemichael, Head of the National ID Program of Ethiopia.

20 See *Linux Foundation Annual Report 2021* at https://www.linuxfoundation.org/tools/linux-foundation-annual-report-2021/

21 See the Apache Foundation website at https://apache.org

22 See *The Apache Software Foundation - Annual Report - FY2021* at https://www.apache.org/foundation/docs/FY2021AnnualReport.pdf