Operational Framework: Institutional Controls

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1 Introduction and Overview (Arek)

To realize the promise and prospects of a Big Data society and avoid its security and confidentiality perils, institutions are updating operational frameworks governing business, legal, and technical dimensions of their internal organization and interactions with the outside world. This chapter describes how the common good can be served by framing these types of institutional rules and processes to ensure a greater user control over personal data, as well as large scale risk management and interoperability for data sharing between and among institutions.

The control points traditionally relied upon as part of corporate governance, management oversight, legal compliance, and enterprise architecture must evolve and expand to match operational frameworks for Big Data. An operational framework used for a Big Data-driven organization requires a balanced set of institutional controls. These institutional controls must support and reflect greater user control over personal data and large scale interoperability for data sharing between and among institutions. Core capabilities of these controls include responsive rule-based systems governance and fine-grained authorizations for distributed rights management. In the following sections we explore the emergence of the Big Data Society, outline the ways to support it in the institutional context, and draft the future directions of research and development.

2 The New Realities of Living in a Big Data Society (Arek)

Sustaining a healthy, safe, and efficient society is a scientific and engineering challenge going back to the 1800s, when the Industrial Revolution spurred rapid urban growth, creating huge social and environmental problems. The remedy then was to build centralized networks that delivered clean water and safe food, enabled commerce, removed waste, provided energy, facilitated transportation, and offered access to centralized healthcare, police, and educational services. Those networks formed the backbone of the society as we know it today.

These century-old solutions are however becoming increasingly obsolete and inefficient. We have cities jammed with traffic, world-wide outbreaks of disease that are seemingly unstoppable, and political institutions that are deadlocked and unable to act. We face the challenges of global warming, uncertain energy, water, and food supplies, and a rising population and urbanization, that will add 350 million people to the urban population by 2025 in China alone [12].

It does not have to be this way. We can have cities that are protected from pandemics, energy efficient, have secure food and water supplies, and have much better government. To reach these goals, however, we need to radically rethink our approach. Rather than static fixed systems, separated by function — water, food, waste, transport, education, energy — we must consider them as dynamic, data-driven networks. Instead of focusing only on access and distribution, we need the networked and self-regulating systems, driven by the needs and preferences of the citizens. We also need to create the channels for the society to agree upon and communicate those needs.

To ensure a sustainable future society, we must use our new technologies to create a *nervous system* maintaining the stability of government, energy, and public health systems around the globe. Our digital feedback technologies are today capable of creating a level of dynamic responsiveness that our larger, more complicated modern society requires. We must reinvent the systems of the societies within a control framework: sensing the situation, combining these observations with models of demand and dynamic reaction, and finally using the resulting predictions to tune the system to match the demands.

The engine driving this new nervous system is Big Data: the newly ubiquitous digital data, now available about all aspects of human life. We can analyze patterns of human experience and ideas exchange within the *digital breadcrumbs* that we all leave behind as we move through the world: call records, credit card transactions, GPS location fixes, among others. By recording our choices, these data tell the story of our lives. And this may be very different from what we decide to put on Facebook or Twitter; our postings there are what we choose to tell people, edited according to the standards of the day and filtered to match the persona we are building. Mining social networks can give some great insights about human nature [3, 23, 37]; who we really are is however even more accurately determined by where we spend our time and which things we buy, rather than just what we say we do [22].

The process of analyzing the patterns within these digital breadcrumbs is called reality mining [11, 27], and through it we can learn an enormous amount about who we are. The Human Dynamics research group at MIT have found that we can use them to tell if we are likely to get diabetes [28], or whether we are the sort of person who will pay back loans [29]. By analyzing these patterns across many people, we are discovering that we can begin to explain many things — crashes, revolutions, bubbles — that previously appeared to be random acts of God [25]. For this reason the magazine Technology Review named our development of reality mining as one of the ten technologies that will change the world [14].

3 The New Deal on Data (Arek)

The digital breadcrumbs we leave behind provide clues about who we are and what we want. This makes these personal data immensely valuable, both for public good and for private companies. As European Consumer Commissioner, Meglena Kuneva said recently, "Personal data is the new oil of the Internet and the new currency of the digital world" [19]. This new ability to see the details of every interaction can be however used for good or for ill. Therefore, maintaining protection of personal privacy and freedom is critical to our future success as a society. On one hand, we need to enable even more data sharing for the public good; on the other, we need to do a much better job in protecting the privacy of the individuals.

A successful data-driven society must be able to guarantee that our data will not be abused; perhaps especially that government will not abuse the power conferred by access to such fine-grain data. To achieve the positive possibilities of the new society, we require the *New Deal on Data*, workable guarantees that the data needed for public good are readily available while at the same time protecting the citizenry [27]. We must develop much more powerful and sophisticated tools to use personal data to both build a better society and to protect the rights of the citizens.

The key insight that motivates the creation of the New Deal on Data is that our data are worth more when shared, because these aggregated data inform improvements in systems such as public health, transportation, and government. For instance, we have demonstrated that data about the way we behave and where we go can be used to minimize the spread of infectious disease [21,28]. Our research has reported how we were able to use these digital breadcrumbs to track the spread of influenza from person to person on an individual level. And if we can see it, we can stop it. Here the result of sharing our personal data is that we can build a world where the threat of infectious pandemics is greatly diminished.

Similarly, if we are worried about global warming, these shared, aggregated data can show us how patterns of mobility relate to productivity [26]. In turn, this provides us with the ability to design cities that are more productive and, at the same time, more energy efficient. But in order to be able to obtain these results and make a greener world, we need to be able to see the people moving around; this depends on many people willing to contribute their data, even if only anonymously and in aggregate.

While concrete examples such as better health systems and more energy efficient transportation systems motivate the New Deal on Data, there is an even greater public good that can be achieved by efficient and safe data sharing. To enable sharing of personal data and experiences, we need secure technology and regulation that allow individuals to safely and conveniently share personal information with each other, with corporations, and with government. Consequently, the heart of the New Deal on Data must be to provide both regulatory standards and financial incentives that entice owners to share data, while at the same time serving the interests of both individuals and society at large. We must promote greater idea flow among individuals, not just corporations or government departments.

Unfortunately, today most personal data are siloed off in private companies and therefore largely unavailable. Private organizations collect the vast majority of the personal data in the form of mobility patterns, financial transactions, phone and Internet communications, etc.

These data must not remain the exclusive domain of private companies, because then they are less likely to contribute to the common good. These private organizations must be thus the key players in the New Deal on Data framework for privacy and data control. Likewise, these data should not become the exclusive domain of the government, as this will not serve the public interest of transparency; we should be suspicious of trusting the government with such power. Ultimately, the entities who should be empowered to share and make decisions about their data, are people themselves: users, participants, citizens.

The ultimate goal is to provide the society tools to analyze and understand what needs to be done, and to reach the consensus how to do it. This goes beyond the creation of more communication platforms. The assumption that more interactions between users will result in better decisions being made, may be very misleading. Although in the recent years we have seen some great examples of using social networks for better organization in society, for example during political protests [5, 15], we are not even close to the point where we can start reaching consensus about the big problems: epidemics, climate change, pollution. The discussions must be data driven, involving both experts and wisdom of the crowds. The problems we are dealing with as a now global society are not easy. We are responsible for many of them, and being able to tackle them on a global scale is necessary for our, mankind, survival.

4 Personal Data: Emergence of a New Asset Class (Thomas)

It has long been recognized that the first step to promoting liquidity in land and commodity markets is to guarantee ownership rights so that people can safely buy and sell. Similarly, the first step toward creating greater idea and idea flow (‘idea liquidity) is to define ownership rights. The only politically viable course is to give individual citizens rights over data that are about them and in fact, in the European Union these rights flow directly from the constitution. We need to recognize personal data as a valuable asset of the individual that is given to companies and government in return for services.

The simplest approach to defining what it means to own your own data is to draw an analogy with the English common law ownership rights of possession, use, and disposal:

- You have the right to possess data about you. Regardless of what entity collects the data, the data belong to you, and you can access your data at any time. Data collectors thus play a role akin to a bank, managing the data on behalf of their customers.

- You have the right to full control over the use of your data. The terms of use must be opt-in and clearly explained in plain language. If you are not happy with the way a company uses your data, you can remove the data, just as you would close your account with a bank that is not providing satisfactory service.

- You have the right to dispose of or distribute your data. You have the option to have data about you destroyed or redeployed elsewhere.

Individual rights to personal data must be balanced with the need of corporations and governments to use certain data-account activity, billing information, and so on-to run their day-to-day operations. This New Deal on Data therefore gives individuals the right to possess, control, and dispose of copies of these required operational data, along with copies of the incidental data collected about you such as location and similar context.

Note that these ownership rights are not exactly the same as literal ownership under modern law, but the practical effect is that disputes are resolved in a different, simpler manner than would be the case for (as an example) land ownership disputes.

In 2007, one author (Pentland) first proposed the New Deal on Data to the World Economic Forum [38]. Since then, this idea has run through various discussions and eventually helped shape the 2012 Consumer Data Bill of Rights in the United States, along with a matching declaration on Personal Data Rights in the EU. These new regulations hope to accomplish the combined trick of breaking data out of the current silos, thus enabling public goods, while at the same time giving individuals greater control over data about them. But, of course this is still a work in progress and the battle for individual control of personal data rages onward.

The World Economic Forum (WEF) has dubbed personal data as the "New Oil" or resource of the 21st centruy [38]. The discovery of oil and the subsequent development of the oil industry over the past 100 years has spurred not only the development of the automobile industry but also the creation of the global transportation infrastructure, including the massive freeway networks that we see today in the developed nations. The "personal data sector" of the economy today is still in its infancy, its state akin to the oil industry at the late 1890s prior to the development of the Model-T Ford automobile. The productive collaboration between the Government (building the state owned freeways), the private sector (mining and refining oil, building automobiles) and the citizen (the user-base of these services) allowed the develop nations to expand its economies by creating new markets adjacent to the automobile and oil industries.

If personal data as the new oil is to reach its global economic potential, there needs to be a productive collaboration between all the stakeholders in the establishment of a *personal data ecosystem*. As mentioned in [38] a number of fundamental questions about privacy, property, global governance, human rights - essentially around who should benefit from the products and services built upon personal data - are major uncertainties shaping the opportunity. The rapid rate of technological change and commercialization in using personal data is undermining end user confidence and trust.

The current personal data ecosystem is fragmented and inefficient. Too much leverage is currently being accorded to service providers that on-board and register end-users. These siloed repositories of personal data exemplifies the fragmentation of the ecosystem. These repositores contain data of varying qualities. Some are attributes of persons that are unverified, while other represent higher quality data that have been cross-corelated with other data points of the end-user.

For many participants, the risks and liabilities exceed the economic returns. Besides not having the infrastrcuture and tools to manage personal data, many end-users simply do not see the benefit of fully participating in the ecosystem. The current focus of many Internet-based service providers is to capture as much personal data from the end-user and to sell this data into the advertising industry. Personal privacy concerns are thus inadequately addressed at best, or simply overlook in the majority of the cases. The current technologies and laws fall short of providing the legal and technical infrastructure needed to support a well-functioning digital economy.

The report of the World Economic Forum [38] also suggest a way forward by recommending a number of areas where efforts could be directed:

- Alignment of key stakeholders: Citizens, the private sector and the public sector need to work in support of one another. Efforts such as NSTIC [33] – albeit still in its infancy – represents a promising direction for a global collaboration.
- Viewing "data as money": There needs to be a new change in mindset where an individual's personal data items are viewed and treated in the same way as their money. These personal data items would reside in an "account" (like a bank account) where it would be controlled, managed, exchanged and accounted for just like personal banking services operate today.
- End-user centricity: All entities in the ecosystem need to recognize that end-users are vital and independent stakeholders in the co-creation and value exchange of services and experiences. Efforts such as the *User managed Access* (UMA) initiative [2] point in the right direction by designing systems that are user-centric and managed by the user.

5 Enforcing the New Deal on Data (Dazza)

How can we enforce this New Deal? The threat of legal action alone is important, but insufficient, because if you cannot see abuses then you cannot prosecute them. Moreover, who wants more lawsuits anyway? Enforcement can be addressed in significant ways without prosecution of public statute or regulation at all. In many fields, companies and governments rely upon multi-party frameworks of agreed rules governing common business, legal and technical practices to create effective self-organization and enforcement. These approaches hold promise as a method for using institutional controls to form a reliable operational framework balancing the needs for big data, privacy and access.

One current best practice is a system of data sharing called trust networks. Trust networks are a combination of networked computers and legal rules defining and governing expectations regarding data. With respect to data belonging to individuals, these networks of technical and legal rules keeps track of user permissions for each piece of personal data, and a legal contract that specifies both what you can and cannot do with the data and what happens if there is a violation of the permissions. For example, in such a system all personal data can have attached labels specifying what the data can, and cannot, be used for. These labels are exactly matched by the network's system rules and terms in legal contracts between all the participants stating penalties for not obeying the permission labels. These rules can, and often do, reference or require audits of relevant systems and data use, demonstrating how traditional internal controls can be leveraged as part of the transition to more novel trust models.

Complete tracking and regulation of every aspect of a trust network is not the goal or even desirable in order to achieve effective enforcement. Rather, the rules for a trust network align enforcement with the highest priority issues and those upon which trust of participants is premised. The relevant issues arise from the dynamics of data flows, underlying trust models and contextual scenarios within which the networked data and the relationships of parties in the trust network. When a trust network involves use of personal data, then the user permissions and corresponding limits on use are fundamental to the trust model. In this context, the permissions, including the provenance of the data, should require appropriate levels of audit. A well designed trust network, elegantly integrating computer and legal rules, allows automatic auditing of data use and allows individuals to change their permissions and withdraw data.

Having system rules applicable to the networks, applications and data as well as all the services providers other intermediaries, and the users themselves is the mechanism for establishing and operating a trust network. System rules are sometimes called operating regulations in the credit card context, or known as trust frameworks in the identity federations context, or trading parter agreements in a supply value chain context. There are many general examples of multi-party shared architectural and contractual rules that share the generic characteristic of creating binding obligations and enforceable expectations on all participants in scalable networks. Another common characteristic of the system rules design pattern is that the participants in the network can be widely distributed across very heterogeneous business ownership boundaries, legal governance structures and technical security domains. Yet, the parties need not agree to conform all or most aspects of their basic roles, relationships and activities in order to connect to to systems of a trust network. Cross-domain trusted systems must, by their nature, focus mandatory and enforceable rules narrowly upon the critical items that must be commonly agreed in order for that network to achieve it's purpose.

For example, institutions participating in credit card and automated clearinghouse debit transactional networks are subject to profoundly different sets of regulations, business practices, economic conditions and social expectations. The network rules focus upon the topmost agreed items affecting interoperability, reciprocity, risk and revenue allocation. The knowledge that fundamental rules are subject to enforcement actions is one of the foundations of trust as well as a motivation to prevent or address violations before they trigger penalties. A clear example of this approach can be found with the Visa Operating Rules, covering a vast global real-time network of parties that agree to rules governing their roles in the system as merchants, banks, transaction processors, individual or business card holders and other key system roles.

A system like this has made the interbank money transfer system among the safest systems in the world and the daily backbone for exchanges of trillions of dollars, but until recently such systems were only for the 'big guys. To give individuals a similarly safe method of managing personal data, the Human Dynamics research group here at MIT, in partnership with the Institute for Data Driven Design, co-founded by John Clippinger and one author (Pentland), have helped build openPDS (open Personal Data Store) http://openPDS.media.mit.edu for project information and https://github.com/HumanDynamics/openPDS for the open source code.

The openPDS system is a consumer version of a personal cloud trust network and we are now testing it with a variety of industry and government partners. Soon, sharing your personal data could become as safe and secure as transferring money between banks.

The Human Dynamics Lab has applied the system rules approach to development of integrated business, technical architecture and rules large scale institutional use of personal data stores, available as an example under MIT's creative commons license by MIT, at: github.com/HumanDynamics/

The capacity to apply the appropriate methods of enforcement for a trust network depend upon a clear understanding and agreement among parties about the purpose of the trusted system and the respective roles or expectations of those connecting is as participants. Therefor, an anchor is needed to a clear context of a big data operational framework and institutional controls appropriate for access and confidentiality or privacy. The following section posits the trust model and signature traits of such a context, through the lens of the New Deal on Data.of those connecting is as participants. Therefor, an anchor is needed to a clear context of a big data operational framework and institutional controls appropriate for access and confidentiality or privacy. The following section posits the trust model and signature traits of such a context, through the lens of the New Deal on Data.

6 Essential Elements of the New Deal of Data (Brian)

The New Deal on Data restates the controls and expectations people have with respect to their private property and personal affects and applies it to their personal data and online affects. Institutional controls must align with the New Deal on Data by providing responsive, rule-based systems governance and fine grained authorizations for distributed rights management.

Our lives are embedded within institutions. We are citizens of countries and cities, receive services from telecom operators, and search for things to buy in online stores. Almost any action we perform generates data, and those recordings of our lives are an important part of the Big Data promise. The data are not curated by us, but are collected 'as is' - and reflect our lives.

Today, all of the data people generate are stored in closed silos belonging to institutions providing customer services. Phone providers own mobility traces for their users, while music services store and use data on musical preferences.

For these data to be useful to society, the silos must be opened, and the data must be integrated across institutions far more than they are today. If access to data for the purpose of creating value–either for the user or the society–is very limited, it does not matter how big the data is. The value of the data lies not just in the fact that they exist, but rather the knowledge, understanding, and wisdom we gain from them. It is an even bigger challenge to open up the data from disparate silos. Accessing multi-faceted data, which exist under multiple jurisdictions, about people may be prohibitively difficult. Silos are hard to crack open. Despite these difficulties, such data, not just big, but deep, covering multiple facets of a person's life, may be invaluable for research.

Recently, we have shown how challenging, but also feasible, it is to open such institutional Big Data. In the Data For Development (D4D) Challenge [1], the telecom operator Orange opened access to a large dataset of call detail records (CDRs) from the Ivory Coast. Working with the data as part of a challenge, teams of researchers came up with life-changing insights for the country. For example, one team developed a model for how disease spread in the country and demonstrated that information campaigns based on one-to-one phone conversations among members of social groups can be an effective countermeasure [20]. In releasing and analysing this data, the privacy of the people who generated the data was protected not only by the technical means, such as removal of the Personally Identifiable Information (PIIs), but also by legal means, with the researchers signing an agreement they will not use the data for re-identification or other nefarious means. As we have seen in several cases, such as the Netflix Prize privacy disaster [24] and other similar privacy breaches [32], true anonymization is extremely hard. Some of the weight of privacy protection must rest on the legal framework.

Opening data from the silos by publishing static datasets is important, but it is only the first step. We can do even more substantial things when the data is available in real time and can become part of a society's nervous system. Epidemics can be monitored and prevented in real

[1] http://www.d4d.orange.com/home

time [28], underperforming students can be helped, and people with health risks can be treated before they get sick [8]. The same data can potentially be used for stalking, burglarizing one's home, and as justification to charge people more for an insurance policy.

In the Unique in the Crowd project [9], de Montjoye et al. showed that even though human beings are highly predictable [30], we are also very unique. Having access to one dataset, it is easy to uniquely fingerprint someone based on just few datapoints, and use this fingerprint to discover their true identity. The higher the resolution of the data, the easier it gets to identify a person from this type of data.

The question of privacy in this context effectively becomes a question of control:

Who can release the data of one's movements? To whom? How much and how often? The data are collected by the institution. The data are about people who not even be aware that they exist, and certainly do not own them. People cannot decide upon them, cannot review them. People cannot delete them. Very few parties can use the data, even if people wanted them to. For systems to be truly data driven and capable of transitioning to the networked and highly dynamic assumptions of a big data economy, the key agreements reflected in trust networks must reflect a new deal. The operating frameworks of successful institutions are capable of balancing interests in access, confidentiality and every day reliance upon big data including personal and other sensitive information. The institutional controls relevant to achieve, maintain and appropriately adapt these balances support and reflect adherence to the fair information practices.

[Footnote: HEW Report, OECD rendition, EU Directive, DHS/NSTIC version, MGL FIPA and culminating in New Deal on Data adaptation].

Within the existing legal frameworks, it is possible to change the vantage point of the data ownership and put the user, the entity about whom the data are, in control. This may be achieved by providing a copy of the data to a personal silo, which is provided by or on behalf of the user. The user would become the owner of their copy of the data, or whenever possible the original, in the old Common Law sense with the right to use, transfer, and delete the data. An example of such a mechanism in an institutional context is the Blue Button initiative [2], where the patients can get a copy of their health records. Once the copy is with the user, they can do with it as they wish: give it to someone, make it public, do research on it, destroy it.

Under such a system, users can accumulate data about themselves from multiple sources. Information on healthcare records, mobility patterns, favorite movies, etc., all belong to the user and can be accessed based on their authorization. This changes how and what data that can be obtained for the purpose of research and providing services. Rather than gaining access to the movements of millions of people from a telecom operator, one can potentially gain access to a smaller number of much richer datasets describing the users from the mobility, health, and shopping perspectives. New startups would not have to build the user profile from scratch, but can offer competitive services based on the user's previously-collected data from day one. Users can immediately get better services, using their data in new places.

The first, operational challenge of moving towards end-user data ownership on a large scale, is to create an ecosystem where such user-owned data are known and accessible. We are currently embedded in a feudal framework: Facebook owns the data generated by and about their users, and provides access to this data to 3rd parties that the user might or might have not directly authorized. It is reasonably easy for users to download all their data from these services, such as Facebook. It is reasonably easy to put it on a public file-sharing site, such as a user's personal Dropbox, or even create a myself-API, becoming a self-hosted API to one's own personal data. The challenge is to have clients talk to this API and provide services, rather than going to Facebook for one's data. Today, virtually no online service is configured to access user data directly from the user. This is at least partly due to their not being an open, widely implemented standard for providing self-hosted data services for users. We have done slightly better on the Internet scale with identity: one can deploy their own OpenID server fairly easily, and many services will allow the user to sign in. We should be heading in the same direction with data.

[2]http://www.healthit.gov/bluebutton

7 Transitioning End-User Assent Practices (Arek)

The way the user grants authorizations to the data she owns is not a trivial matter. The flow of personal information, such as location data, purchases, health records, etc. can be very complex. Every tweet, every geo-tagged picture, every phone call, and every purchase with credit card, provide the user's location not only to the primary service, but also to all the applications and services that have been authorized to access and re-use these data. The authorizations may come from the end-user or, often, be granted by the collecting service, based on an umbrella terms of service, allowing the re-use of the data. Implementation of such flows was a crucial part of the Web 2.0 revolution, realized with RESTful APIs, mashups, and authorization-based access. The way the data travel between the services has however became arguably too complex for a user to handle and manage.

Increasing the amount of data the user controls and granularity of this control is meaningless if it cannot be exercised in an informed way. For many years, the End User License Agreements (EULAs), long incomprehensible texts have been accepted blindly by the end-user, trusting they have not agreed to anything that could harm them. The process of granting the authorizations cannot be too complex, as it would prevent the user from understanding her decisions. At the same time, it cannot be too simplistic, as it may not sufficiently convey the weight of the privacy-related decisions. It is a challenge in itself, to build the end-user assent systems that allow the user to understand and adjust their privacy settings. Complex EULAs do not promote the privacy of the users, effectively pushing them to press *I Agree* in every presented window. The consequences of those assent actions are not emphasized; as the data being collected is becoming increasingly complex and our computations more sophisticated, every act of sharing can lead to great benefits to the society, but also make the users vulnerable.

This gap between the interface, the single click, and the effect, can render the data ownership meaningless; the click may wrench people and their data into systems and rules that are antithetical to fair information practices, such as is prevalent with todays end-user licenses in cloud services or applications. Managing the potentially long term and opposite dynamics fueled by old deal systems operating simultaneously with the new deal systems is an important design and migration challenge during the transition to a Big Data economy. During this transition and after the New Deal on Data is no longer new, personal data must continue to flow in order to be useful. Protecting the data of people outside of the user-controlled domain is very hard without a combination of cost effective and useful business practices, legal rules, and technical solutions. For these reasons, the Human Dynamics group has focused upon and collaborated with partners to support the clarification of business, legal, and technical short- and longer-term viable solutions.

We envision Living Informed Consent, where the user is entitled to know what data is being collected about her by which entities, empowered to understand the implications of data sharing, and finally put in charge of the sharing authorizations. We suggest the readers ask themselves a question: *Which services know which city I am in today?*. Google? Apple? Twitter? Facebook? Flickr? This small application we have authorized a few years ago to access our Facebook check-ins and forgot since then? This is an example of a fundamental question related to user privacy and assent, and yet finding the answer to it may be surprisingly difficult in today's ecosystem. We can hope that most of the services treat the data responsibly and according to user authorizations. In the complex network of data flows however, it is relatively easy for the data to leak to services careless with it or simply malicious [6].

It is clear that the promise of the Big Data can only be realized when the data is shared, available even more than it is today. For this, the user herself should be put in the driver's seat and made decisions about who is authorized to see what and for what purpose. To realize this, the solutions for making the user decisions well though-through must be designed and implemented.

8 Business, Legal and Technical Dimensions of Big Data Systems (Dazza)

When it comes to data intended to be accessible over networks-whether big, personal or otherwise-the traditional container of an institution makes less and less sense. Institutional controls apply, by definition by or to some type of institutional entity such as a business, governmental or religious organization. A combined view of the business, legal and technical facts and circumstances surrounding big data is necessary to know what access, confidentiality and other expectations exist. The relevant contextual aspects of big data of one institutional is often profoundly different from that of another. As more and more organizations use and rely upon big data, a single formula for institutional controls will not work for increasingly heterogeneous business, legal and technical environments in play.

Looking at an institution as a business, legal and technical system is one effective approach for dealing with the inherent complexity of managing heterogeneous and distributed networks of actors and interactions. The business models, interface-point operational practices and relevant assumptions must be consistent and frequently carefully agreed at an executive level by and with institutions as part of the value exchange involving data and access to high value, mission critical or sensitive systems and services. The applicable legal frameworks, common assumptions regarding likely allocation of liability and resolution of disputes in the event of losses and expected types of contracting practices need to reflect and support the business goals and purposes for the system and data. When technical standards are selected, configured and applied to systems they too must support and reflect the business and legal dimensions and be supported and reflected by those dimensions.

Once a systems view is adopted, there is a tractable starting point to narrow or broaden the scope of view to see the smaller and larger systems and to make better and more effective use and control of big data. Within a given institution, there may in fact be many different discernable institutions and corresponding systems and any given system of one institution will frequently in fact exist across many different discernable institutions. However, defining as a system the thing to which institutional controls apply provides an achievable and measurable basis for balancing privacy, access and other interests in big data.

Many organizations are structured with clear leadership on business, legal and technical issues functionally assigned to top level executive roles. Business issues are typically allocated to roles such as CEO, COO or CFO, while leadership on legal issues is commonly assigned to roles like general counsel and regulatory compliance and technical leads are often the roles of CIO, CTO or CSO. Having top level leadership for each of the business, legal and technical aspects of a trust network is a critical success factor.

9 Big Data and Personal Data Institutional Controls (Thomas)

The phrase "institutional controls" refers to safeguards and protections by use of legal, policy, governance and other non-strictly technical, engineering or mechanical measures. The phrase institutional controls in a big data context can perhaps best be understand by examining how the concept has been applied to other domains. The most prevalent use of institutional controls, per se, has been in the field of environmental regulatory frameworks.

A good example of how this concept supports and reflects the goals and objectives of environmental regulation can be found in the policy documents of the EPA. This following definition is instructive, and is part of the Institutional Control Glossary of Terms [35]:

> "Institutional Controls - Non-engineering measures intended to affect human activities in such a way as to prevent or reduce exposure to hazardous substances. They are almost always used in conjunction with, or as a supplement to, other measures such as waste treatment or containment. There are four categories of institutional controls: governmental controls; proprietary controls; enforcement tools; and informational devices."

Going deeper, the article by DeMeo and Doar [10] defines institutional controls thusly:

> ”Institutional controls are administrative and legal controls that help minimize the potential for human exposure to contamination and/or protect the integrity of the physical remedy. They can include recorded restrictive covenants, but land use laws and regulations, deed restrictions, department consent orders, and conservation easements are all institutional controls.”

In domains of information technology, this approach is most commonly reflected as “enterprise controls” related to security. See, for example, the report [18] stating: ”Enterprise mobility technologies, especially those designed to retrofit enterprise controls on top of consumer mobile devices, are rapidly evolving. This was a message we heard loud and clear in the study.” This study and analysis also reveals much about the internal controls needed to accommodate mobile device use by employees. In both capacities as employee, consumer and other roles, the use of mobile devices triggers myriad legal, policy and other implications for institutional controls.

In the legal domain, this concept frequently emerges under the moniker “regulatory compliance” or “legal compliance” anchored in legal and regulatory frameworks such as HIPAA and Sarbanes-Oxley (SOX). These statutory legal frameworks require covered organizations to established integrated sets of governance, legal, transactional, security and other internal controls to avoid violating the rules. The institutional controls are accomplished in tight integration with engineering and other measures in order to ensure compliance and to control legal and security risk. The use of institutional controls of this type are fundamental methods for achieving and maintaining the transition to a digital, networked and big data footing for any private company, government agency or other organization.

Consider again the analogy of institutional controls in the context of environmental law, and how these types of measures can be applied in the big data, privacy and access context to digital environments. Given the relatively mature and stable state of environmental regulation, there is much to be learned by examining this context of institutional controls. Environmental regulatory compliance with waste management cleanup requirements could include institutional controls restricting land use on adjacent property. In these situations, it is possible that the remediation strategy requires significant use of land outside the property boundaries of the cleanup site. In these cases, the regulators and the land owner responsible for the regulated property must find ways to ensure a common approach among multiple owners and across multiple property environments. Use of measures such as a clauses on the relevant deeds, an enforceable consent order or regulations and zoning rules are examples of more severe institutional controls that can be employed to ensure consistent and effective actions are taken across ownership and real property boundaries.

See, for example, FDEP, Division of Waste Management [13] which states that "...RMO III does contemplate contamination beyond the Property boundaries, which would require agreement by the adjacent owners to put an RC on their properties as well."

The concept of an "institutional control boundary" is especially clarifying and powerful when applied to the networked and digital boundaries of an institution. In the context of Florida's environmental regulation frameworks, the phrase is applied to describe the various types of combinations risk management levels related to target cleanup standards and extend beyond the area of a physical property boundary. Also see a recent University of Florida report on Development of Cleanup Target Levels (CTLs) [7] stating "Risk Management Options Level III, like Level II, allows concentrations above the default groundwater CTLs to remain on site. However, in some rare situations, the institutional control boundary at which default CTLs must be met can extend beyond the site property boundary."

The EPA provides considerable information on the nature and use of institutional controls, including situations when the situational scope extends to adjacent properties owned by third parties. See, generally, *EPA Hazardous Waste Corrective Action Guidance on Institutional Controls* [35]. Also see: *Institutional Controls Bibliography: Institutional Control, Remedy Selection, and Post-Construction Completion Guidance and Policy, December 2005* [34].

When institutional controls would apply to "separately owned neighboring properties" a number of issues arise. Engagement with affected third parties, requiring the party responsible for site cleanup to use "best efforts" to attain agreement by third parties to institute the relevant institutional controls, use of third party neutrals to resolve disagreements regarding the application with institutional controls or forcing an acquisition of the neighboring land by forcing the party responsible to purchase the property of by purchase of the property directly by the EPA. See [36].

In the context of big data, privacy and access, institutional controls are seldom if ever the result of government regulatory frameworks such as are seen in the environmental waste management oversight by the EPA. Rather, institutions applying measures constituting institutional controls in the big data and related information technology and enterprise architecture contexts will typically employ governance safeguards, business practices, legal contracts, technical security, reporting and audit programs and a various risk management measures. Inevitably, institutional controls for big data will have to operate effectively across institutional boundaries just as environmental waste management internal controls must sometimes be applied across real property boundaries and may subject multiple different owner to enforcement actions corresponding to the applicable controls. Short of government regulation, the use of system rules as a general model are one widely understood, accepted and efficient method for defining, agreeing and enforcing institutional and other controls across business, legal and technical domains of ownership, governance and operation.

The use of system rules and integrated participation agreements by developers and end-users is a way to ensure intended operational frameworks conform to applicable institutional controls. The example of “living consent” described below, demonstrates how institutional controls comprised of legal and definite workflow measures in concert with technical methods can result in a higher level of performance while appropriately balancing legitimate interests of various parties regarding use and access to personal data.

Following the recommendation of the World Economic Forum recomendations of treating personal data stores in the manner of bank accounts [38], there are a number of infrastructure improvements that need to be realized if the personal data ecosystem is to flourish and deliver new economic opportunities. We believe the following infrastructure improvements are necessary for the coming personal data ecosystem:

- *New global data provenance network*: In order for personal data to be treated like bank accounts, the origin information regarding data items coming into the data store must be maintained [17]. In other words, the provenance of all data items must be accounted for by the IT infrastructure upon which the personal data store operates. The heterogeneous provenance databases must then be interconnected in order to provide a resilient and scalable platform for audit and accounting systems to track and reconcile the movement of personal data from the respective data stores.

- *Trust network for computational law*: In order for trust to be estblished between parties who wish to exchange personal data, we foresee that some degree of “computational law” technologies may have to be integrated into the design of personal data systems. Such technologies should not only verify terms of contracts (e.g. terms of data use) against user-defined policies but also have mechanisms built-in to ensure non-repudiation of entities who have accepted these digital contracts. Efforts such as [1, 2] are beginning to bring non-repudiation and enforceability of contracts into the technical protocol flows.

- *Development of Insitutional Controls for Digital Institutions*: Currently there are a number of proposal for the creation of virtual currencies (e.g. BitCoin [4], Ven [31]) in which the systems have the potential to evolve into self-governing “digital institutions“ [16]. Such systems and insitutions that operate on them will necessitate the development of a new paradigm to understand the aspects of institutional control within their context.

10 Scenarios of Use in Context (Dazza)

Supporting the effective development of institutional controls for big data requires an understanding of how to define and work with the applicable context surrounding the scenarios within which the big data exists. In particular, the New Deal on Data will require a set of Institutional Controls involving governance, business, legal and technical aspects that are knowable only with reference to the relevant context of a factually based scenario of use. The following scenarios demonstrate signature features of the New Deal on Data in various contexts and serve as an anchor to evaluate what Institutional Controls are well aligned.

10.1 Example Scenario: Research Systems

Computational Social Science (CSS) studies are based on data collected often with an extremely high resolution and scale. Using computational power combined with mathematical models, such data can be used to provide insights into human nature. Much of the data collected, for example mobility traces are sensitive and private; most individuals would feel uncomfortable sharing them publicly. The need for solutions to ensure the privacy of the individuals has grown alongside the data collection efforts.

The data collection in the CSS context is based on the informed consent of the participants. Countries have different bodies regulating such studies, for example Institutional Research Boards (IRBs) in the US. Although certain minimal requirements for implementing informed consent exist[TODO: reference], they are often not very well suited for the large-scale studies, where the amount and sensitivity of the data calls for sophisticated privacy controls. As the scale of the studies grows, in terms of the number of participants, collected bits per user, and duration, the EULA-style informed consent is no longer sufficient and makes it hard to claim that participants in fact expressed informed consent.

This year we have deployed a 1,000 phones study at Technical University of Denmark, where we handed out mobile phones to freshmen students in order to study their networks and social behavior in the important change moment of their lives, when they join the university. The study, called SensibleDTU, uses not only data collected from the mobile phones (location, Bluetooth-based proximity, call and sms logs etc.) but also data collected from social networks, questionnaires filled out by participants, behavior in economic games and so on. As the data is collected in the context of the university, there is potentially a big issues of students feeling obliged to participate in the study, feeling that their grades may depend on it, or that the data may influence their grades. In this context, we see the implementation of Living Informed Consent not only as a technical mean to put participants in control of the data we collect, but also to convey the message about the opt-in nature of the study, the boundaries of the data usage, and parties accessing the data.

It is not feasible to explain the terms and answer all the questions to all 1,000 students personally. The controls must be self-explanatory as much as possible, and guide the user from the first opening of the link to the study to the grant of the authorizations. At the same time, every click made by the user, should be an expression of an informed decision, so the user journey must be a balance of guidance and understanding. For this reason we have created a set of web applications, allowing the users to enroll into the study, express informed consent, and interact with their data.

As the study will last for several years, hopefully allowing us to see the life of a student from the very first friendships made until the graduation party, the consent must remain alive. It is again a matter of balance: we do not want the participants to feel under constant surveillance (as they are not, the data is used mostly in aggregated form), at the same time to remember that in fact, the data is being collected and used. We are still trying to understand how to achieve this equilibrium: how often should we remind the users about the collection effort? should they re-authorize applications from time to time? We see a great hope in the applications we create for the users to provide certain services, simple such as life-logging where they can see how active they are, what are their top places etc. and more advanced, such as artistic visualizations of their social networks. Making the user aware of the data by transforming them into value, can greatly benefit the privacy, making users constantly aware what is being collected, but also what kind of value they can get out of it.

When a study of such scale is deployed, the particular experiments and sub-studies may not be exactly defined from the very beginning. The initial deployment is a creation of a testbed, where shorter or longer experiments can take place; for example part of the population may participate in the experiment of quantifying the impact of feedback application on their activity levels. Being able to create such experiments in an efficient way is a huge value for the researchers. To do that in the most frictionless way, we give the users the choice to opt-in to those additional experiments, providing some financial or other benefits. This is only possible if there is a notion of identity of the participants, stronger and more useful than a piece of paper with a signature. This identity allows us to reach out to people, offer them additional experiments, and let them agree or disagree to them.

This touches upon the re-usability of data, as the new experiments may require additional data to be collected, but also have access to all the existing data, based on user authorization. We can imagine going even further, where entirely different studies can re-use participants data from a previous study based on their authorization. When the data are owned buy the users, they are free to authorize access to them to any party that requests it. We can see a New Deal on Data pattern here: rather than services (studies) talking to each other about the user data, they talk directly to the users, seeking their authorization. This can address a very important problem in the research context, the data re-use in a privacy-aware manner. Rather than publishing a static dataset, where the users have lost control over their data, live and fresh data can be continuously accessed by any study that the user agrees to be a part of.

Many studies will be willing to offer money or other value for the access to the data. Other will provide the user the opportunity to have new data collected. This way, the data collection becomes an opportunity for the user to enrich their personal dataset, and to benefit from it in the future. Join our study and we will provide you with a smartphone and collect your movement patterns for a year; we will do science and you will gain new data that can get you better value or deals in different services. You may now be eligible for a different study. Or your music recommendation may get better, because your music service can make a use of this extra data. Your data.

10.2 Scenarios of Use Today, Tomorrow and the Day After

By inquiring into and noting the four facets of relevant context described above, it is possible to describe the basic material contours of any scenario within which big data exists such that the operational framework and adequate approaches to access, use, confidentiality and other key interests can be sustainably balanced. In a commercial scenario the relevant people might be a consumer, merchants, banks, products manufacturers, third party app developers and individual members of that consumers bowling team. The relevant transactions might be a purchase of goods by the consumer from the merchant and the corresponding app that was embedded in the goods and the downstream transaction of involving the consumer now transacting with the merchant bowling alley and interacting with a bowling team, with whom activity and sports performance data are shared and aggregated and further mashed up. The rest of the context can be described for any given scenario and this all could be expressed specifically rather than by role simply by running a report from the system to indicate it was in fact John Doe, of openpds.org/owner/571 purchasing a smart bowling ball from Bowl-a-Tronic of bowlappgood.com/store/221 and so on for each party that played a role in the relevant scenario. The same techniques, used for scenarios in other economic sectors and social endeavors shed light on the fundamental nature and implications of big data and options for the use of operational frameworks acting across domains to balance privacy and access, among other intersts.

This book represents a high value opportunity to take stock of the current state and dominant trends related to big data and help to illuminate important choices at a moment of early adoption, dynamic innovation and wide open possibilities. By contemplating the relevant contexts of todays scenarios of use in, say, the fields of education, entertainment, government, manufacturing, transportation and many other core anchors of human activity, we have traction to postulate how todays prevailing trends are likely to result and what changes perhaps quite small but of profound long term impact could lead to materially different better outcomes. Consider that if the essence of the New Deal on Data were accepted today, or soon, the nature, tenor, capabilities and experience of living by future generations could be unrecognizably better. Simply extrapolate from the current anomalous practices regarding personal data and individual identity and push forward the timeline by 5, 10, 20 years and beyond. The current trajectory ends up with dystopian scenarios that effectively reverse hard fought but easily lost constitutional deal of the United States and social compact of common law societies.

By contrast, by adopting the New Deal on Data now it is possible to set conditions that promote prosperity and invention even before the New Deal on Data frameworks are formally launched. This is because the uncertainly and confusion about the basic premises and expectations around personal data and identity will be resolved and so investment and risk taking on a firm foundation can be unleashed. The value of big data can be accessed at less direct cost and lower risk when uncertainties about privacy liability are addressed and significant the new value is created by enabling wide scale permission based access to personal data and computations about such data. Adopting use of personal data services in phases, such one economic sector, transaction type or data type at a time enables access to the lower costs and new value in a reasonable manner that allows for time to prepare for and stage each phase of adoption. By staging and phasing the New Deal on Data typical objections to change based on grounds of cost, disruption or over regulation can be addressed. Policy incentives can further address these objections, such as allowing safe harbor protections for conduct of organizations operating under the rules of a trust network. Policy makers can resolve other difficulties by combinations of strategic transition management methods like allowing safe harbor compliance delays, or approving alternative adoption paths and granting other non-substantive waivers to ease any burdens of migrating to new business methods. The key point is change management can be designed to achieve enough value at every phase for every key stakeholder group such that self interests and the broader interests are all aligned with the public good.

11 Future Research (Brian)

Our traditional methods of testing and improving government, organizations, and so on are of limited use in building a data driven society. Even the scientific method as we normally apply it doesn't work as well as we might expect, because there are so many potential connections that our standard statistical tools generate less than useful results.

The reason is that with such rich data, you can easily uncover misleading or unactionable correlations. For instance, lets imagine we discover that people who are unusually active are more likely to get the flu. This is a real example: when we examined the minute-by-minute behavior of a small university community a real-time flow of gigabytes per day for an entire year we noticed that an unusual level of running around often predicted onset of the flu [21]. But if we can only analyze the data using traditional statistical methods, we have the problem of discerning why this is true. Is it because the flu virus makes us more active in order to spread itself more quickly? While it is more likely that interacting with many more people than usual makes you more likely to catch the flu, you can't be sure that this is the true cause based on the real-time stream of data alone.

The point here is that normal analysis methods don't suffice to answer these sorts of questions, because we dont know all the possible alternatives and so we cant form a limited, testable number of clear hypotheses. Instead, we need to devise new ways to test the causality of connections in the real world. We can no longer rely on laboratory experiments; we need to actually do the experiments in the real world, typically on massive, real-time streams of data.

11.1 Research on Design and Deployment of Big Data Systems

In order to acheive low risk, high value outcomes efficiently, design and deployment of the coming global wave of big data systems should apply top current research. To understand and address the unique problems and prospects associated with big personal data, the relevant context must be identified and corresponding rules-driven capabilities must be designed into the underlying systems.

People and/or systems can determine the right rules to apply to data when the right information is reliably attached to or logically associated with that data in a standard manner. Any system that can make, use, receive or share big data must be capable of associating provenance and purpose for all data in a common and actionable manner. Requiring a lot of narrative documentation and background about the nuances and circumstances surrounding every data set is both impractical and counterproductive. By contrast, a small amount of metadata listing or reliably linking the parties, transactions, systems and provenance of the data would suffice. This relevant context together with the data forms the basis for accountable analysis on big personal data.

It is important for science and research to develop further solutions and options ensuring contextually appropriate rules can be applied by big data systems. For rules to be effectively applied, systems must not only be able to establish which rules apply but also support the right functional capabilities and have appropriate information structure, format and meta-data.

Some capabilities will likely be essential to all big data systems, such as highly scalable active storage, standard methods for integration with other big data systems and a processing architecture enabling high speed statistical analytics. But there are and will continue to emerge multiple types of big data systems. Some functions or controls will likely be important - or even feasible - only for certain types of future systems. For instance, it is reasonable to expect some systems will specialize in enormous volumes of entirely non-personal data from many real-time sources (e.g. for soil science, materials engineering, astronomy, etc) while other big data systems will hinge upon mass quantities of highly sensitive personal information (e.g. for clinical medicine, education and life-long learning, social entertainment, etc).

While some capabilities, such as ingesting and processing astronomical data-sets, will be unique to only a subset of big data systems it is reasonable to anticipate that data will be increasingly cross-tabulated, merged and otherwise shared with other systems and data. It can be nearly impossible to conclusively predict for the entire life of a system what data will be received by, created in or transmitted from that system at the design phase. This prediction is all the harder to make when the systems are intended for big data.

The four contextual facets of people, interactions, technology and data provide a sound underpinning for the design of new big data and web 2.0 systems. The existing systems design and development processes of establishing business cases, use cases, agile stories, functional requirements, etc. do not reliably identify the factors most relevant to use of big data, especially in a web 2.0 massively distributed environment. The four facets can also be used to analyze appropriate, required or prohibited uses for existing big data systems. However, it can be difficult to extract the relevant information from or apply any effective control on systems used for big data but designed to achieve limited purposes in hierarchical closed environments.

Big data, by its nature, represents a new set of business, legal and technical capabilities and requirements. Most of the worlds systems today are not capable of ingesting, storing, using or dynamically flowing big data with other systems. Considering that a) big data is of high value immediately and higher value in the short and long terms, and b) the young but competitive marketplace of big data system components, platforms, applications and other solutions is a hotbed of innovation it can be predicted that a transition to big data systems will continue. The key observation is that virtually all big data systems have yet to be designed, implemented, customized or deployed. Institutions that are the current early adopters of todays big data system will soon replace those systems and the rest of the world will adopt big data systems in phases over time. Based upon this observation,

11.2 Research on Big Data for Design of Institutions

Using massive, live data to design institutions and policies is outside of our normal way of managing things. We live in an era that builds on centuries of science and engineering, and the standard choices for improving systems, governments, organizations, and so on are fairly well understood. Therefore our scientific experiments normally need only consider a few clear alternatives (i.e., plausible hypotheses).

But with the coming of big data, we are going to be operating very much out of our old, familiar ballpark. These data are often indirect and noisy, and so interpretation of the data requires greater care than is usual. Even more importantly, a great deal of the data is about human behavior, and the questions are ones that seek to connect physical conditions to social outcomes. Until we have a solid, well-proven and quantitative theory of social physics, we wont be able to formulate and test hypotheses in the way we can when we design bridges or develop new drugs.

Therefore, we must move beyond the closed, laboratory-based question-and-answering process that we currently use and begin to manage our society in a new way. We must begin to test connections in the real world far earlier and more frequently than we have ever had to do before, using the methods my research group and I have developed for the Friends and Family study or the Social Evolution study. We need to construct Living Laboratories communities willing to try a new way of doing things or, to put it bluntly, to be guinea pigs in order to test and prove our ideas. This is new territory and so it is important for us to constantly try out new ideas in the real world in order to see what works and what doesnt.

An example of such a Living Lab is the ‘open data city just launched by one author (Pentland) with the city of Trento in Italy, along with Telecom Italia, Telefonica, the research university Fondazione Bruno Kessler, the Institute for Data Driven Design, and local companies. Importantly, this Living Lab has the approval and informed consent of all its participants they know that they are part of a gigantic experiment whose goal is to invent a better way of living. More detail on this Living Lab can be found at http://www.mobileterritoriallab.eu/

The goal of this Living Lab is to develop new ways of sharing data to promote greater civic engagement and exploration. One specific goal is to build upon and test trust-network software such as our openPDS (Personal Data Store) system . Tools such as openPDS make it safe for individuals to share personal data (e.g., health data, facts about your children) by controlling where your data go and what is done with them.

The specific research questions we are exploring depend upon a set of personal data services designed to enable users to collect, store, manage, disclose, share and use data about themselves. These data can be used for the personal self-empowerment of each member, or (when aggregated) for the improvement of the community through data commons that enable social network incentives. The ability to share data safely should enable better idea flow among individuals, companies, and government, and we want to see if these tools can in fact increase productivity and creative output at the scale of an entire city.

An example of an application enabled by the openPDS trust frame work is sharing of best practices among families with young children. How do other families spend their money? How much do they get out and socialize? Which preschools or doctors do people stay with for the longest time? Once the individual gives permission, our openPDS system allows such personal data to be collected, anonymized and shared with other young families safely and automatically.

The openPDS system lets the community of young families learn from each other without the work of entering data by hand or the risk of sharing through current social media. While the Trento experiment is still in its early days, the initial reaction from participating families is that these sorts of data sharing capabilities are valuable, and they feel safe sharing their data using the openPDS system.

The Trento Living Lab will let us investigate how to deal with the sensitivities of collecting and using deeply personal data in real-world situations. In particular, the Lab will be used as a pilot for the New Deal on Data and for new ways to give users control of the use of their personal data. For example, we will explore different techniques and methodologies to protect the users privacy while at the same time being able to use these personal data to generate a useful data commons. We will also explore different user interfaces for privacy settings, for configuring the data collected, for the data disclosed to applications and for those shared with other users, all in the context of a trust framework.

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