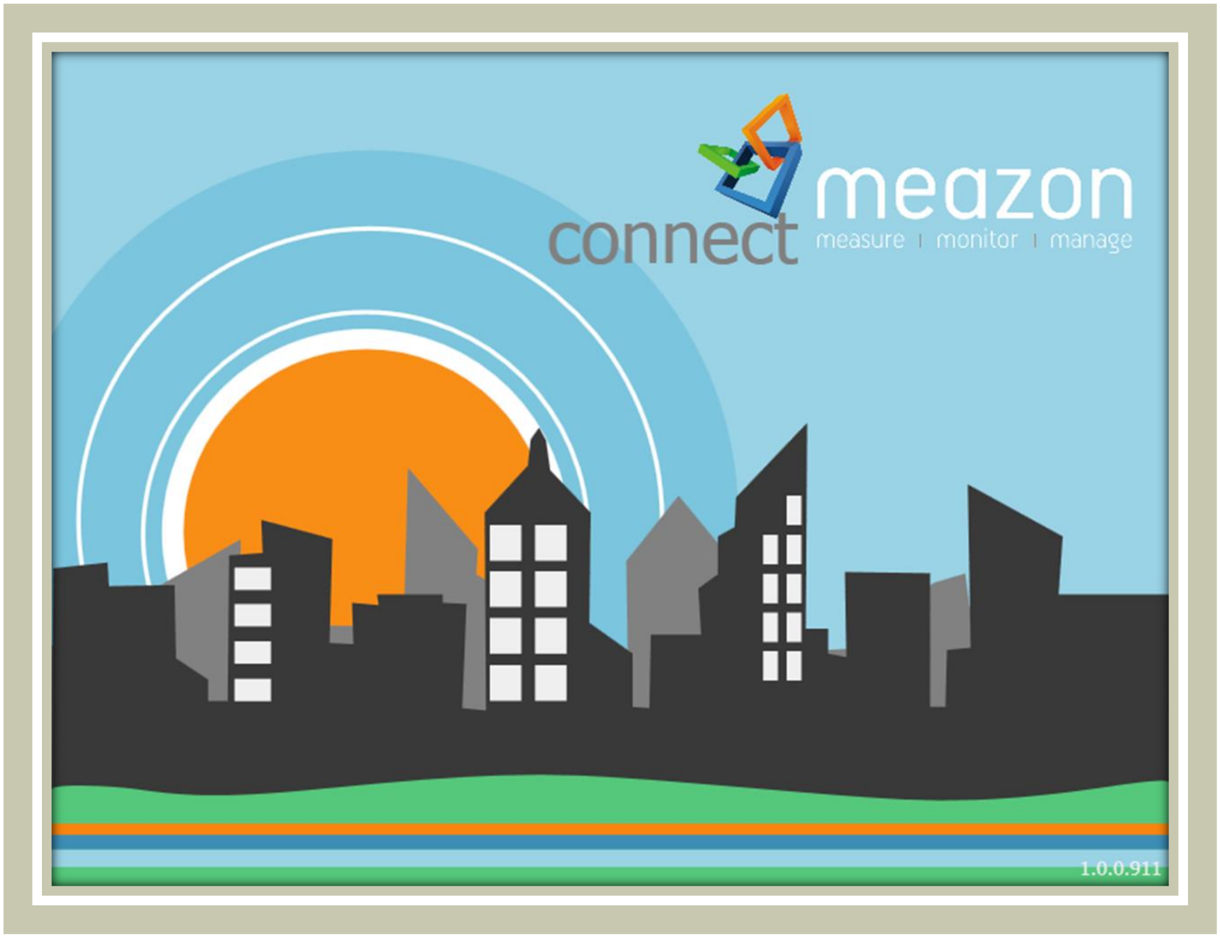

WHITE PAPER

BUILDINGS' ENERGY PROFILING

The Energy Saving Spiral and the basic need for sub metering

meazon
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WHITE PAPER

BUILDINGS' ENERGY PROFILING

I. BUILDINGS' ENERGY PROFILE IMPACT ON CORPORATE RESULTS

Understanding the type and amounts of energy consumed by various systems within a building is fundamental in creating an energy policy and driving consumption down. Building sectors are responsible for approximately 42% of the world's total annual energy consumption [1]. Most of this energy is used for the provision of lighting, HVAC systems and electricity based office appliances. Buildings in the developed countries account for 50%-60% of electricity use [2, 3].

Savings can start from the modest and conservative 2% due to simple behavioral changes of the building's inhabitants and systems' managers and go up to the impressive 20%++ due to systems automation introduction as well as building envelope interventions. For a portfolio of buildings belonging to the same company, an annual saving of 2% that can be raised to 20%, under certain conditions, could be translated to millions of Dollars or Euros bottom line results, improving EBITDA drastically.

IMPROVE EBITDA

The "hidden treasure" of buildings' energy performance sustainable improvement could be exploited if companies decided to build energy policies based on constantly improving buildings energy profile understanding.

II. ENERGY SAVING SPIRAL

Companies can fully exploit the potential of the energy saving spiral resulting in considerable, EBITDA improving cost cuttings as well as sustainability, following usually a step by step approach depicting the maturity level of the organization called to implement those changes.

Energy savings and sustainability usually demand changes in the human behaviors before anything else and strong change management processes are usually the basis upon which the company's energy policy and targets will be built.

There are usually four levels of energy saving engagements an organization could utilize and since they are iterative processes we call them cycles. These cycles have some basic characteristics:

1. They are iterative processes and as such they tend to achieve their target "better" when companies run them repetitively
2. Each cycle usually has as on average a "rooftop" of savings that can be achieved
3. In order to pass from one cycle to the next one, someone usually needs a business case for the investment required and a management decision
4. Passing from one cycle to another increases investment requirements but also expected savings on a sustainable mode
5. All of them require energy consumption measurement on a per quarter of hour, half hour or hour basis, and
6. Apart from the first introductory cycle they all require the use of energy submeters in order to track the success of each cycle, measure savings and create business cases

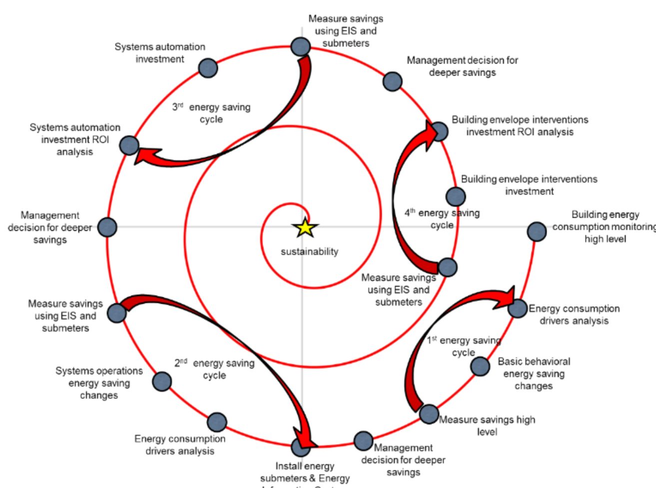

FIGURE 1: BUILDINGS ENERGY SAVING SPIRAL

A. Energy Saving Cycle 1

The energy saving cycle 1 is the entry level of energy savings and sustainability that a building/company needs to enter in order to gain some insight of its energy profile. It usually requires total building energy consumption data on a per quarter of an hour, half hour or hour level and can provide analysis and feedback on generic building energy characteristics and behaviors, such as energy profile in relation to external temperatures, occupancy, square meters or other available data. Simple baseline analysis can be performed and Utility Cost Accounting as well as Carbon Accounting can be monitored.

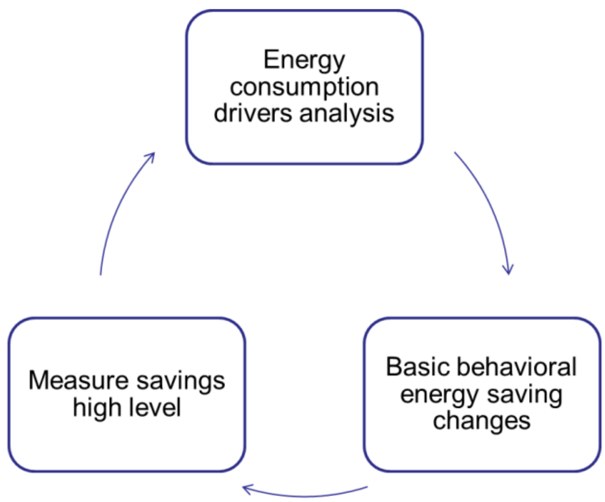

FIGURE 2: ENERGY SAVING CYCLE 1

Based on the above, actions to reduce energy spending include usually behavioral and manual ad/hoc changes to building's total energy profile, such as manual reduction of energy loads in case the utility cost accounting exercise predicts monthly costs out budgeting target, or recommendations towards end users regarding their energy consumption daily behaviors such as turning off pcs and monitors, lights or other energy consuming devices when not in need. Finally, heuristic analysis driven actions can be tested such as increasing HVAC set points and observing possible savings.

This approach is a starting point into energy consumption and sustainability analysis and action plan and clearly paves the way for the next step of building's more detailed energy profile analysis that employs the use of sub metering and Energy information Systems.

B. Energy Saving Cycle 2

During this cycle the building gets into a more detailed and analytical measurement of energy consumption by employing the use of latest web based sub metering technologies, giving the opportunity to the Energy Manager of the building to analyze deeply the energy consumption drivers and relate them to independent variables such as internal and external temperature, occupancy, square meters, CO_2, humidity, presence among others. This way detailed energy baseline regression models can be developed per geography, floor, department, type of system etc… and more detailed behavioral and systems operations decisions and heuristic models can be derived.

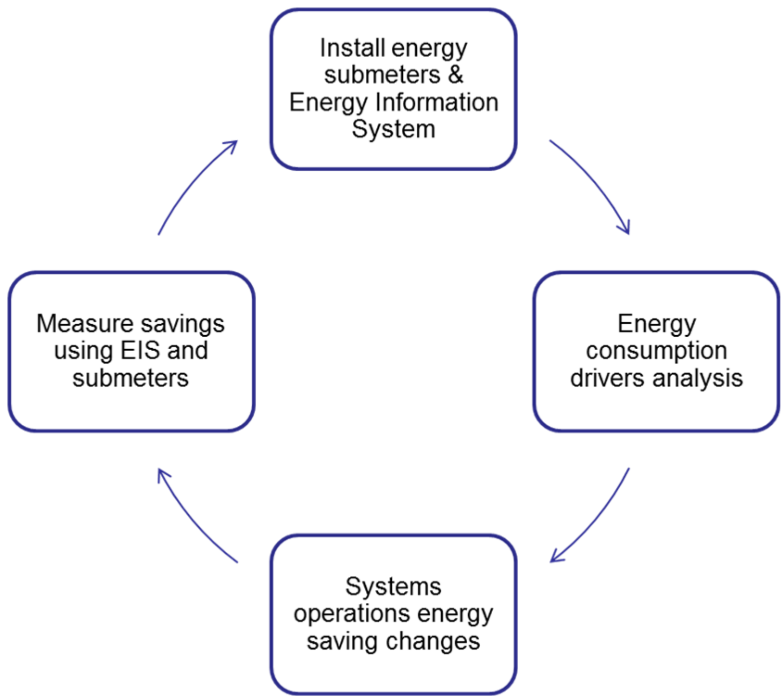

FIGURE 3: ENERGY SAVING CYCLE 2

This stage clearly can be iterative since someone could start with a relatively small number of submeters and as analysis progresses and business benefits become apparent, more submeters would be installed that lead to tangible and measurable benefits adhering to specific ROI. This way the analysis and actions can become deeper by analyzing more subsystems of the same system e.g. HVAC systems in a multi floor and multi building complex or broader analyzing more systems e.g. including to our analysis the lighting system on top of the HVAC system.

Obviously energy savings during this phase increase considerably in comparison to the previous phase, since detailed measurements enable deeper analysis and produce much more reliable results.

C. Energy Saving Cycle 3

During this cycle the detailed sub meters measurements are used in order to analyze and implement automation systems investments. Automation systems provide the capability to start automating the operation of systems such as heating and cooling, lighting and other electromechanical equipment as part of an algorithmic objective function that leads to energy usage optimization. Automation obviously leads to even higher levels of energy savings, for obvious reasons, compared to manually adjusted set points of operation.

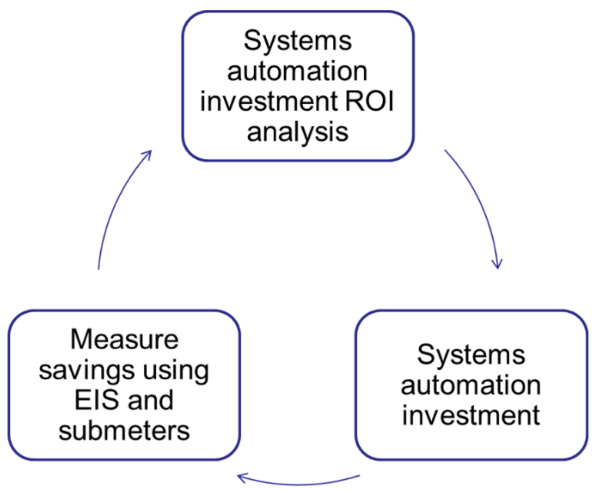

FIGURE 4: ENERGY SAVING CYCLE 3

Energy submeters might be needed during this phase in order for a valid business case and ROI model to be created but also for real time controlled system output values to be used as real time feedback during the implementation of optimization control algorithms.

D. Energy Saving Cycle 4

During this phase building structural interventions investments are considered and analyzed through a business case. Building structural investments relate to buildings insulation, HVAC and lighting systems change among other investments that lead building to become a near zero energy consuming building.

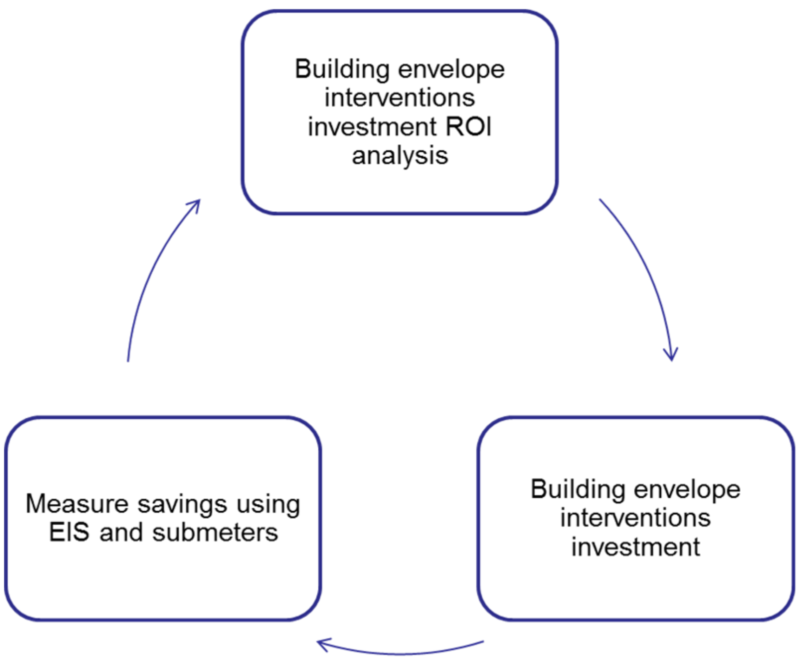

FIGURE 5: ENERGY SAVING CYCLE 4

This phase usually needs a financing model approach using highly detailed measurements from the energy submeters in order to document a well substantiated business case.

III. ENERGY MANAGEMENT INFORMATION SYSTEMS

Energy submeters have gone through revolutionary changes over the last decade. Apart from measuring in high accuracy nowadays they have the ability to communicate their measured data to the internet/cloud and provide the user of the Energy Management system with highly actionable information in a fraction of the time that this was possible before. Information is accessible from everywhere in a secure manner due to the Cloud service and customized reporting and data analytics algorithms can support decision making on energy efficiency actions applicable to all 4 cycles described above.

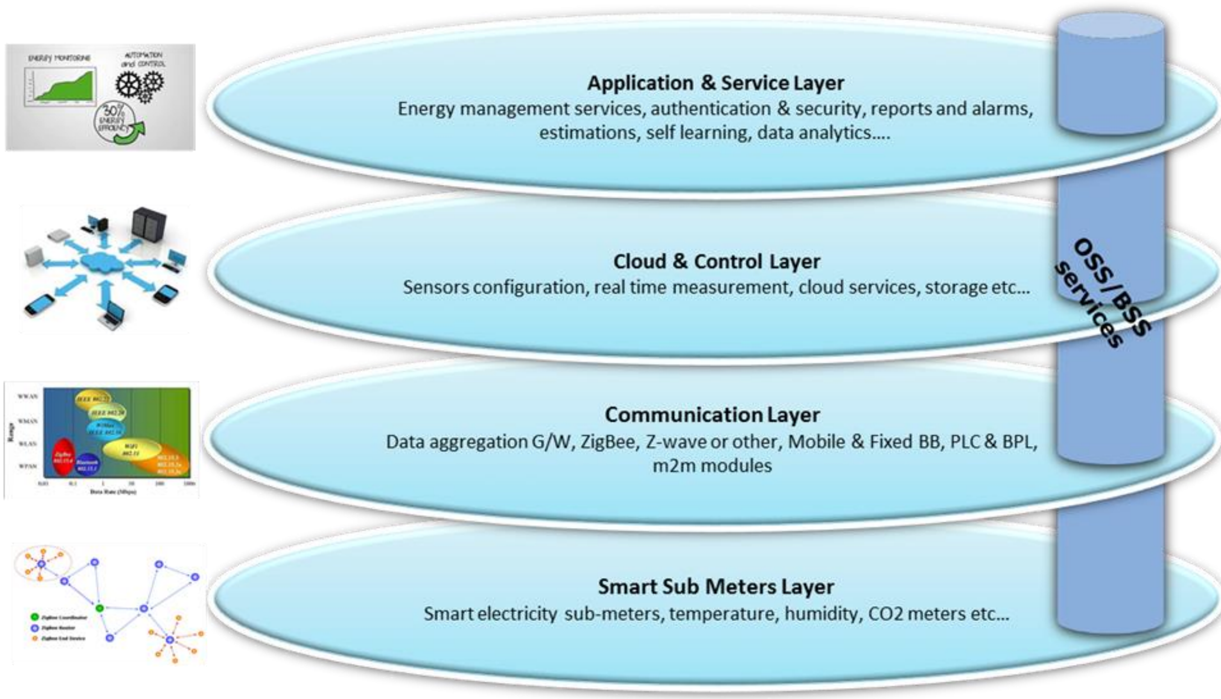

FIGURE 6: ENERGY MANAGEMENT INFORMATION SYSTEM

A. Web enabled Energy Submeters characteristics

Web enabled electricity sub meter is a device capable of providing real-time highly accurate electrical measurements. By the term electrical measurements we mean measurements concerning the electrical behavior of an installation (home, office, industry etc.). Examples of such measurements are Voltage, Current, Active Power, Power Factor, Reactive Power etc. These measurements are transmitted from the metering device wirelessly in a predefined time interval or on demand, and are managed from high level applications in order to be properly displayed, analyzed etc.

Each sub meter is able to take multiple samples per minute and provide the measurements with a low error rate (< %1). Meazon's energy monitoring device is highly compatible with 3-phase as well as 1-phase installations while it also provides embedded (or supports embeddable) relay switches in order to remotely control specific loads and even schedule their time of operation.

The communication between energy submeters and a local data collection device could be implemented over a wireless communication protocol for saving installation time and money. ZigBee is a low-cost, low-power, wireless mesh network standard. The low cost allows the technology to be widely deployed in wireless control and monitoring applications. Low power usage allows longer life with smaller batteries. Mesh networking provides high reliability and more extensive range. The ZigBee network layer natively supports both star and tree typical networks, and generic mesh networks.

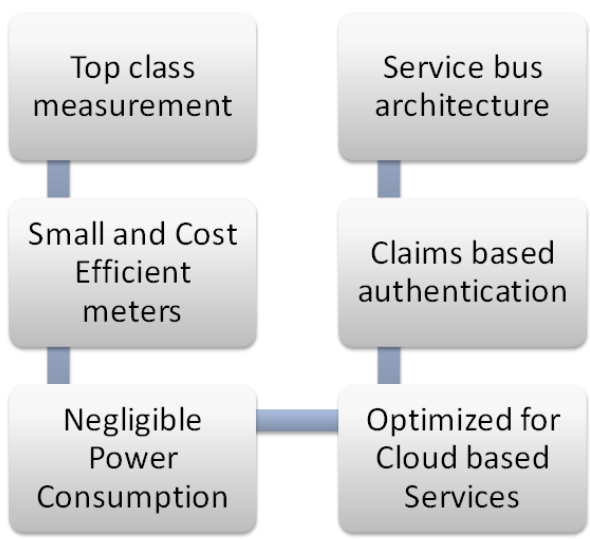

FIGURE 7: SUBMETERS DESIGN CHARACTERISTICS

B. Local Data Collection Communication Characteristics

A local Data Collection device (Gateway) is used to gather data from the submeters and sensors with the following communication capabilities:

1. HTTP transmission of measured values, on user-defined intervals. (Default 5 mins)
2. Persistent Web Socket connection that allows remote control of devices (relay switching, scheduling).
3. MQTT publishing/subscribing for both measurement transmission and remote control.
4. MQTT+HTTP automatic upgrade functionality. (MQTT announcement notifies devices of new available versions, so that they automatically download and install them from corresponding URLs, which are also announced via MQTT)
5. Local HTTP server for quick and easy monitoring of ZigBee network establishment, capable of real time high frequency measurement monitoring, as well as performing administrative tasks on Gateway and ZigBee Network which may vary from determining the IP configuration to defining the role of each phase on a DinRail meter.

Apart from the above, the Gateway periodically stores measurements on a local SQLite database. Storage intervals can be synchronized to those of transmissions (default), also indicating the success of the transmission operations, thus allowing repetitions of potentially unsuccessful ones.

In certain applications where cloud services are not available, due to security/policy /technical restrictions, database registrations can also be used for offline/local purposes, and be retrieved directly, or exported to a variety of popular document formats, such as csv. This allows a higher frequency of measurements, suitable for post processing for analytics purposes.

FIGURE 8: ENERGY SUBMETER & GATEWAY BY MEAZON

The Gateway should support Ethernet, 3G/GPRS, Wi-Fi backhauling interfaces in order to operate in any environment, depending on the availability of the infrastructure in order to meet the lowest possible operational cost.

C. Cloud and Control Layer Characteristics

The Gateway consolidates the measurements and transmits them to a cloud-based backend for further processing. The cloud infrastructure that hosts the respective service should be open, flexible and reliable without a single point of failure. Meazon's cloud service is based on Microsoft Azure. Several web service instances are constantly available and listen for incoming measurements arriving from customer installations. Azure allows for seamless addition of more service instances as customer base grows. Upon arrival, raw measurements are stored in a relational database. Consequently, stored measurements are post-processed to facilitate the production of reports and other analytical processing activities. The Cloud layer is also host to another category of web services that are responsible for routing control messages between the customer and its infrastructure such as on/off and scheduling commands. The Cloud and Control layer infrastructure is operating 24x7 and does not present single points of failure.

D. Application and Service Layer Characteristics

End customers, business partners, integrators as well as ESCOs have full control over existing installations via the Web Portal. On the measurement's front, an authorized end-user can check the health of installed meters, browse real-time indicators such as current power, total energy, daily energy etc., compare aggregates over all types of measurements for a single meter over different time periods, compare aggregates for several meters over the same time period and create reports per quarter / hour / day / month / year for any set of meters. Financial estimations and forecasting as well as buildings energy signature, baseline loads analysis, peak load analysis, heat map drawings and PV and HVAC systems monitoring in relation to temperature among other provide valuable and actionable information even to the non-technical personnel. On the control front, an authorized end-user can turn a meter on or off. Moreover, he/she can set rules that trigger alarms (via email and/or SMS) when energy and/or power during specified period exceed certain limits. Time periods and limits are fully user defined. End customers, business partners, integrators as well as ESCOs can securely access their respective infrastructure using their Gmail account credentials. Support for additional identity providers (Facebook, MSDN) is on the way.

IV. CONCLUSIONS

Energy management as a service can create high value for buildings including immediate cash flow optimization through reduced energy bills and commercial value increase over the years. The initial investment usually is reasonable since the project can start small and increase gradually as benefits for the building become apparent. Moreover, according to the ESCO model, initial investment can be minimized following a cost savings sharing scheme.

The energy management platform including smart submeter layer, communication layer, cloud and control layer and application and service layer is of importance in order to support such business models. An open, IP/IOT based, cost efficient and pay as you grow approach can help in the faster adoption rate of such services.

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