International Journal of Computer Networks and Communications Security

VOL. 4, NO. 5, MAY 2016, 153–158
Available online at: www.ijcncs.org
E-ISSN 2308-9830 (Online) / ISSN 2410-0595 (Print)

Contribution to Improving the Monitoring of Distribution and Consumption of Final Energy (Water, Electricity, Gas) in Developing Countries

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ABSTRACT

If electricity, water and gas production has almost doubled since the 1970s, the share of developing countries has continued to contract. Public operators of final energy distribution in developing countries face a lot of problems such as measuring of consumption, bill collection, etc. The main objective of this paper is to propose a model based on recent measurement technologies (Internet of Things, big data, cloud computing, etc.) for energy distribution and consumption monitoring in developing countries. Our approach will help facilitate access to the final energy to households and businesses, the real-time measuring of consumption, collection of invoice amounts, detection and alert on failures, etc. This approach will also allow operators to increase their production and distribution capacity in developing countries. The different results obtained during simulations show the relevance of our approach.

Keywords: *Big Data Analytic, Cloud Computing, Development, Energy, Internet of things (IoT), Real Time, Smart Metering.*

1 INTRODUCTION

The rapid growth of the population and the transformation of lifestyles and economic development in developing countries [1] increase pressure on water resources, electricity and gas disponibility that are already limited due to the size of its needs: food production, processing industry, health facilities, domestic, etc. Environmental issues, including climate change, are added to these pressures. The production, supply, sanitation and proper management of these resources are key elements to achieve the main objective for development policy, namely the fight against poverty.

In developing countries, the producers and providers of the final energy face problems such as counting of consumption. Indeed, in most of these countries, people continue using conventional meters or prepaid meters. Field workers are frequently recruited to note consumer volume. Producers and suppliers are also faced with bill collection problems, detection and repair of breakdowns, etc. The lack of monitoring of consumption is usually the cause of power outages, non-renewal of infrastructure, inability to expand the distribution network and increase production capacity. For their part, consumers generally have difficulty adequately meet their needs. They also face a tracking problem of consumption. In addition to the quantity, quality, consumers are struggling to track and control their consumption.

The main objective of our research is to provide an optimal solution for the distribution and consumption of final energy such as water, electricity and gas in developing countries. This solution will allow households and businesses easy access to these resources. For their part, public operators that provide these resources should ensure better availability of the latter. They will also establish bills and recover easily revenues from businesses and households based on their consumption.

In the continuation of this paper, section 2 presents the state of the art on recent measurement technologies. In section 3, we present our approach for monitoring distribution and consumption of final energy in developing countries. Section 4 presents the results of simulations performed on the basis of a test platform. Lastly, the fifth and last section presents conclusion.

2 STATE OF THE ART ON RECENT MEASUREMENT TECHNOLOGIES

2.1 Smart meter

A smart meter is a meter have said AMR technologies (Automated Meter Reading) [2] which measures in detail and precise, and possibly in real time, consumption of electricity, water or gas. The data transmission is by radio waves or power line carrier (PLC) to the distribution network manager in charge of counting.

2.2 Internet of things

The Internet of Things (IoT) is an environment in which objects, animals or people are provided with unique identifiers and the ability to transfer data over a network without requiring human-to-human or human-to-computer interaction [3]. IoT has evolved from the convergence of wireless technologies, micro-electromechanical systems (MEMS) [4] and the Internet. The concept may also be referred to as the Internet of Everything. A connected object is electronic equipment that can communicate with a smartphone, a touch pad and/or computer. That object can send and receive information, this through a wireless connection, Bluetooth or WiFi. The main advantage is the interactivity, the ability to retrieve information or to send statistics, create rules, etc.

2.3 Big data

Big Data refer to data sets that become so large that it becomes difficult to manage with conventional data management tools [5].

The revolution brings Big Data can be explained by two phenomena. On the one hand, the nature of the data has changed. The source is not only businesses, but especially the users themselves, now generate content: text, images, video, data, etc. On the other hand, the dynamic exchange detonated the speed at which this content is distributed, since everything is now shared in real time. Big data have the following attributes: volume, variety, velocity, variability and complexity [6]. Big Data analytics is increasingly needed to make use of the data generated by the Internet of Things [7][8].

2.4 Cloud computing

Cloud computing refers to a model for a pervasive practice network access on request to a shared pool of configurable computing resources pool (eg, networks, servers, storage, applications and services) that can be provisioned quickly and released with minimal management effort [9] . This cloud model has five essential characteristics (on self-demand services, access to the wide network, resource pooling, rapid elasticity, measured service, multi Tenacity), four deployment models (cloud public, private cloud, cloud community, hybrid cloud). The cloud model is also composed of three service models: IaaS, PaaS and SaaS [10].

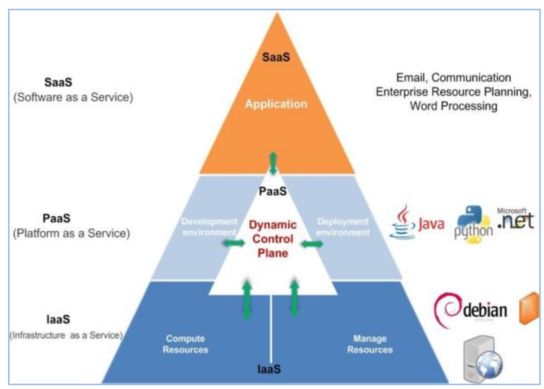

Fig. 1. Overview of different types of Cloud Computing

3 SUGGESTED SOLUTION

In most developing countries, Internet of things networks are almost nonexistent. We suggest first the establishment of Internet of things networks in these countries.

Secondly, for each type of resource (water, electricity, gas), we suggest build and improve the distribution network. In particular, we propose to integrate at each level of the distribution network of Internet of things.

For each type of subscription (water, electricity, gas), each subscriber is identified and has a smart meter. This is connected firstly to the distribution system, and secondly to the IoT network.

Thus, we can enable or disable the remote subscriber. Thus, only persons authorized will have their connection activated. Smart meters periodically and automatically send consumption data to the data collection system integrated to the IoT network. This will also determine in real time the consumption of the subscriber. All data collected are transmitted to the provider control subsystem. These data that come from probes are mass data; for this we recommend the use of big data under big data system to store and process them.

Once recovered, these fields are stored permanently in the data warehouse or data warehouse. The storage principle is: the data warehouse is a set of servers connected to each one of which is the central server that will receive the storage requests. It will handle rooter information to an available server. The actions that can be performed include, among others: making statistics, calculate the share of the state to be paid by operators to the regulator on the basis of these statistics and generate the invoice that will be sent to the operator.

The vast majority of final energy distribution companies in developing countries have resources that are often limited. They do not have enough resources to deploy private IoT networks. The use of cloud computing will enable businesses to have a powerful IT infrastructure without having to invest in software and hardware. Cloud Computing will help reduce operating costs and enable SMEs to use their resources to their projects of expansion and quality.

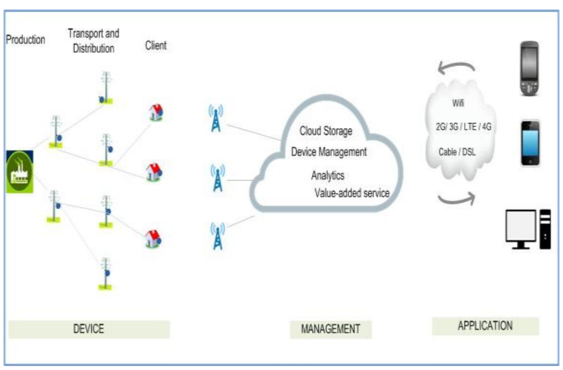

Fig. 2. Overview of architecture of proposed solution

Like smart meters, power plants, transmission and distribution stations shall be equipped with sensors connected to the IoT network. So they will be able to send information about quantities of distributed energy. Thus, we can know at any moment what is the amount of resource that passes through each point. This will also help detecting faults at this level and sending alert. Breakdowns can be repaired very quickly.

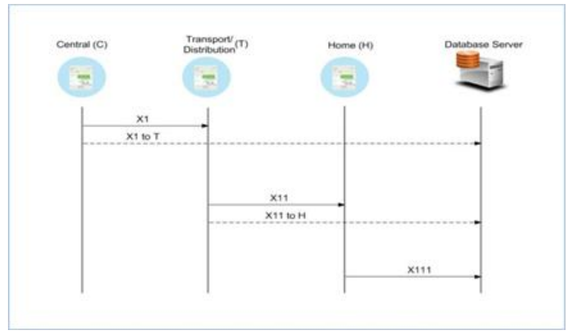

Fig. 3. Overview of architecture of proposed solution

We noticed that payments of post-paid bills are usually made to agencies or through intermediaries. This not only wastes time to subscribers, this is also one of the main causes of late payments. This is due mainly to the fact that in developing countries, most households do not have bank accounts with which they transact. It would be interesting to encourage households to have bank accounts. As motivator, they propose a reduction of the costs of transactions and account maintenance fees. Banks will then automatically deduct the amounts of accounts receivable invoices. It will use the data repository and data from the billing system for water suppliers, electricity and gas. The bank has a duty to report any anomaly that occurs, for example when the subscriber no longer has sufficient funds.

Broadband networks (3G, 4G, etc.) are increasingly implanted in developing countries. These networks allow for real-time applications. It is therefore desirable to develop real-time applications as a value-added service allowing subscribers to view real-time energy consumption, to be informed of their bills with maturities, to settle these bills, to make claims.

4 SIMULATION

4.1 Simulation platform

To make sure of better results, it is set up architecture of collect, storage and analyzes data. The diagram of figure 4 describes the architecture of simulation.

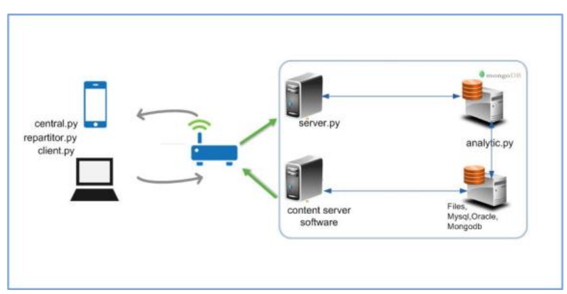

Fig. 4. Overview of simulation platform

```
import socket
import datetime
import time
from random import randint

def getdate(n,a):
    if ((a%4==0 and a%100!=0) or a%400==0):
        jm = (0,31,60,91,121,152,182,213,244,274,305,335,366)
    else:
        jm = (0,31,59,90,120,151,181,212,243,273,304,334,365)
    for m in range(1,13):
        if jm[m]>=n:
            return [n-jm[m-1], m, a]

subscriber_number="3"

for i in range(1,2):
    for hour in range(1,24):
        time.sleep(30.0)
        a=(getdate(i,2016))
        x,y,z=a
        b=str(x)+"/"+str(y)+"/"+str(z)
        qte=randint(10,99)
        s = socket.socket(socket.AF_INET, socket.SOCK_STREAM)
        host = '10.2.6.169'
        port = 8000
        s.connect((host, port))
        x = datetime.datetime.now()
        x1=str(x).split(" ")
        x2,x3=x1
        x4=x3.split(".")
        x5,x6=x4
        qte2 = str(qte)
        i2 =str(i)
        print(qte2)
        tm = str(b) + "-" + str(hour)+ "-" + str(x5) + "-" +subscriber_number  + "-" + qte2 +
         "-" + "1"
        print(tm)
        s.send(tm.encode('utf_8'))
        file = open("central.txt", "a")
        file.write(tm)
        file.write('\n')
        file.close()
        file = open("central_to_transport.txt", "w")
        file.write(qte2)
        file.write('\n')
        file.close()
        s.close()
```

Fig. 5. Central.py

```
import socket
import datetime
import time
from random import randint

def getdate(n,a):
    if ((a%4==0 and a%100!=0) or a%400==0):
        jm = (0,31,60,91,121,152,182,213,244,274,305,335,366)
    else:
        jm = (0,31,59,90,120,151,181,212,243,273,304,334,365)
    for m in range(1,13):
        if jm[m]>=n:
            return [n-jm[m-1], m, a]

subscriber_number="1"

for i in range(1,2):
    for hour in range(0,24):
        time.sleep(30.0)
        a=(getdate(i,2016))
        x,y,z=a
        b=str(x)+"/"+str(y)+"/"+str(z)
        file = open("transport_to_client.txt", "r")
        oneline = file.readline()
        recu = int(oneline)
        qte=randint(0,recu)
        s = socket.socket(socket.AF_INET, socket.SOCK_STREAM)
        host = '10.2.6.169'
        port = 8000
        s.connect((host, port))
        x = datetime.datetime.now()
        x1=str(x).split(" ")
        x2,x3=x1
        x4=x3.split(".")
        x5,x6=x4
        qte2 = str(qte)
        i2 =str(i)
        print(qte2)
        tm = str(b) + "-" + str(hour)+ "-" + str(x5) + "-" +subscriber_number
        + "-" + qte2 + "-" + "3"
        print(tm)
        s.send(tm.encode('utf_8'))
        file = open("client.txt", "a")
        file.write(tm)
        file.write('\n')
        file.close()
        s.close()
```

Fig. 6. Client.py

```
import socket
import time
import datetime
import os
import MySQLdb
def get_db():
    from pymongo import MongoClient
    mongodb_server = MongoClient('10.2.6.169:27017')
    db = mongodb_server.society
    return db
def info_left(info, separator):
    vinfo = info.split(separator)
    x, y = vinfo
    return x
def info_right(info, separator):
    vinfo = info.split(separator)
    x, y = vinfo
    return y
def info_midle(info, separator):
    vinfo = info.split(separator)
    x, y, z = vinfo
    return y
serversocket = socket.socket(
            socket.AF_INET, socket.SOCK_STREAM)
db = get_db()
cursor = db.consumption.find({})
for document in cursor:
    contenu = str(document).split(",")
    a,z,b,c,d,e,f,g,h,i,j = contenu
    Hour=info_right(a, ": ")
    y=info_right(z, ": ")
    Nature = info_midle(y, "'")
    Month=info_right(b, ": ")
    y=info_right(g, ": ")
    Idm = info_midle(y, "'")
    y=info_right(c, ": ")
    UserDate = info_midle(y, "'")
    Quantity=info_right(d, ": ")
    Year=info_right(e, ": ")
    Line=info_right(f, ": ")
    Identifiant=info_right(h, ": ")
    Day=info_right(i, ": ")
    k=info_right(j, ": ")
    RegistrationDate = info_midle(k, "'")
    print(RegistrationDate)
    database = MySQLdb.connect (host="10.2.6.169", user = "root", passwd = "a", db =
    "society")
    cursor = database.cursor()
    cursor.execute("INSERT INTO consumption (UserDate, Month, Line, Identifiant, Day, Year,
    Idm, Hour,
    RegistrationDate, Quantity, Nature) VALUES (%s, %s, %s, %s, %s, %s, %s, %s, %s, %s, %s)",
    [UserDate, Month, Line, Identifiant, Day, Year, Idm, Hour, RegistrationDate, Quantity,
    Nature])
    cursor.close()
    database.commit()
    database.close()
```

Fig. 7. Analytic.py

4.2 Results


```
{ "_id" : ObjectId("56e6ebf6b8af1314fea4b054"), "Subscriber" : 1, "SubscriberDat
e" : "1/1/2016", "RegistrationDate" : "2016-03-14 17:51:02.695551", "Hour" : 13,
 "Year" : 2016, "Line" : 14, "Quantity" : 379, "Day" : 1, "Month" : 1 }
{ "_id" : ObjectId("56e6ebf9b8af1314fea4b055"), "Subscriber" : 1, "SubscriberDat
e" : "1/1/2016", "RegistrationDate" : "2016-03-14 17:51:05.659736", "Hour" : 14,
 "Year" : 2016, "Line" : 15, "Quantity" : 1388, "Day" : 1, "Month" : 1 }
{ "_id" : ObjectId("56e6ebfcb8af1314fea4b056"), "Subscriber" : 1, "SubscriberDat
e" : "1/1/2016", "RegistrationDate" : "2016-03-14 17:51:08.627922", "Hour" : 15,
 "Year" : 2016, "Line" : 16, "Quantity" : 727, "Day" : 1, "Month" : 1 }
{ "_id" : ObjectId("56e6ebffb8af1314fea4b057"), "Subscriber" : 1, "SubscriberDat
e" : "1/1/2016", "RegistrationDate" : "2016-03-14 17:51:11.616109", "Hour" : 16,
 "Year" : 2016, "Line" : 17, "Quantity" : 1974, "Day" : 1, "Month" : 1 }
{ "_id" : ObjectId("56e6ec02b8af1314fea4b058"), "Subscriber" : 1, "SubscriberDat
e" : "1/1/2016", "RegistrationDate" : "2016-03-14 17:51:14.576294", "Hour" : 17,
 "Year" : 2016, "Line" : 18, "Quantity" : 509, "Day" : 1, "Month" : 1 }
{ "_id" : ObjectId("56e6ec05b8af1314fea4b059"), "Subscriber" : 1, "SubscriberDat
e" : "1/1/2016", "RegistrationDate" : "2016-03-14 17:51:17.548479", "Hour" : 18,
 "Year" : 2016, "Line" : 19, "Quantity" : 275, "Day" : 1, "Month" : 1 }
{ "_id" : ObjectId("56e6ec08b8af1314fea4b05a"), "Subscriber" : 1, "SubscriberDat
e" : "1/1/2016", "RegistrationDate" : "2016-03-14 17:51:20.500664", "Hour" : 19,
```


Fig. 8. Brut data in MongoDb

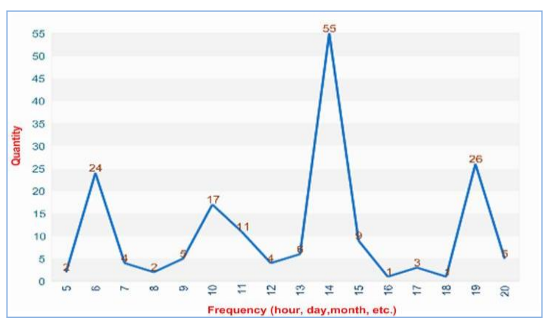

Fig. 9. Evolution of the consumption of a subscriber

Facture	Subscriber	Name	Phone	Month	Year	Quantity	Price	Paid	Rest
1	1	Landry YELOME	772046495	Janvier	2016	7592	189808	189808	0
2	1	Landry YELOME	772046495	Fevrier	2016	7079	176994	176994	0
3	1	Landry YELOME	772046495	Mars	2016	7535	188385	125000	63385
4	1	Landry YELOME	772046495	Avril	2016	5312	132818	0	132818

Fig. 10. Monthly consumption and bills settlement recapitulation

Station	Date	Expected	Received	Discard	Limite
3	2016-05-01	52	50	2	20
3	2016-05-02	49	40	9	20
3	2016-05-03	45	30	25	20
3	2016-05-04	93	64	29	20
3	2016-05-05	55	48	7	20
3	2016-05-06	68	65	3	20
3	2016-05-07	85	70	15	20
3	2016-05-08	75	75	0	20
3	2016-05-09	37	36	1	20
3	2016-05-10	66	66	0	20
3	2016-05-11	37	37	0	20
3	2016-05-12	75	36	39	20
3	2016-05-13	86	78	8	20

Fig. 11. Determination of the difference between received volumes and expected volumes

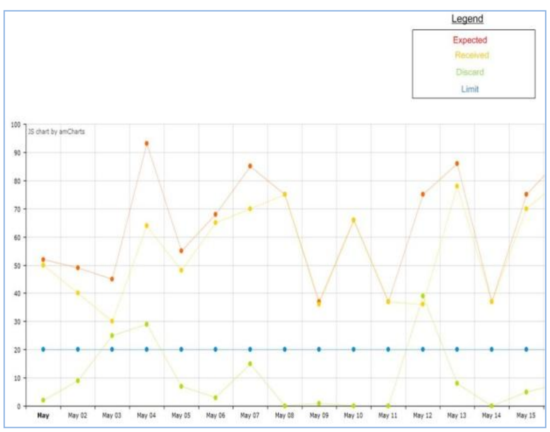

Fig. 12. Real-time curves representing the evolution of receipts volumes and expected volumes

Whenever the discard (expected - received) exceeds the limit, a notification is automatically sent. This difference may be caused by different phenomena. It may be a malfunction. In this case agents as soon intervene to identify and repair the fault. It can also be a robbery from the subscriber. In this case, the subscriber will be punished.

5 CONCLUSION

In this study, we have proposed a new approach that focuses improving the quality of public service provision of water, electricity and gas in developing countries. With the system we propose, suppliers can easily put water, electricity and gas available to households and businesses thanks to the extension and improvement of its distribution network. Households and companies can subscribe without difficulty. Providers can accurately measure consumption of subscribers. Providers can even anticipate future consumption by households and businesses. Thanks to banking, identification and control of subscribers, payments of invoices will be improved and regular. This will allow the suppliers to have regular resources to further expand their networks and improve quality of services they offer.

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