M2M Remote Telemetry and Cloud IoT Big Data Processing in Viticulture

George Suciu, Alexandru Vulpe, Octavian Fratu,
Faculty of Electronics, Telecommunications and IT
University POLITEHNICA of Bucharest
Bucharest, Romania
george@beia.ro, alex.vulpe@radio.pub.ro, ofratu@elcom.pub.ro

Victor Suciu
R&D Department
BEIA Consult International
Bucharest, Romania
victor.suciu@beia.ro

***Abstract*—Current M2M communication platforms are being integrated in cloud IoT applications for providing remote sensing and actuating. Nevertheless, requirements for energy efficiency and resilience in severe operating environments are driving the development of new algorithms and infrastructures. This paper presents a survey of the measurement results for the winegrowing season 2014, as it was seen by an M2M remote telemetry station in cooperation with a big data processing platform and several sensors. We demonstrate the use of recent technologies such as Cloud IoT systems and Big Data processing in order to implement disease prediction and alerting application for viticulture. Finally, the extension of the proposed system for other agriculture applications is discussed.**

Keywords*— *M2M, Remote telemetry, IoT, Big Data, Cloud, Viticulture

I. INTRODUCTION

Research in progress is extending the advances of the machine-to-machine (M2M) paradigm to Internet of Things (IoT) and cloud computing, by developing highly innovative and scalable service platforms that enable secure-, smart- and partly-virtualised-services [1]. Many see the world of IoT as the ultimate futuristic one, where smart devices are connected together to make human life easier, everything, including agriculture, becoming smart.

The possibilities of M2M, IoT and cloud computing are endless [2]-[4], but the technological (and not only) challenges are enormous. In a few years from now, wirelessly connected machines will form a new web. But it will only be of value if the torrent of data that is generated by these sources can be stored, processed, analysed and interpreted.

This paper addresses some of the current gaps and designs solutions for one of the biggest technological challenges at the moment. These are represented by: how cloud computing is applicable to real-time data for large-scale and embedded applications such as big data for agriculture [5], thus opening new horizons in the highly demanding world of IoT, enriched and completed by the cloud paradigm. We present measurement results from a remote telemetry platform for viticulture applications that demonstrate how big data processing can decentralize the concept of the current cloud operation for answering the demands of IoT applications that are distributed in nature.

Also, we introduce in this paper SlapOS [6], the first open source operating system for Distributed Cloud Computing. SlapOS is based on a grid computing daemon called *slapgrid* which is capable of installing any software on a PC and instantiate any number of processes of potentially infinite duration of any installed software. SLAP stands for “Simple Language for Accounting and Provisioning” enabling a configurable cloud environment in terms of the OS and the software stack to manage without the need for virtualization techniques. The architecture follows the master-slave concept, with slave machines at home hosting services and data, and a central scheduler ‘master’ that contains a catalogue of services and publishes them in a directory on a slave node. Furthermore, the master node is based on an Enterprise Resource Planning (ERP) model to handle process allocation optimization and billing, at the same time [7].

With IoT and its subset M2M of communications we use different types of RTUs (Remote Telemetry Units) and sensors that monitor and transmit important information such as temperature, precipitation, wind speed and leaf wetness from selected locations. Moreover, IoT enables the collection, enrichment and distribution of a wide variety of data over heterogeneous networks and protocols to an IP cloud platform, as the RTUs will transmit sensor data over GSM/GPRS using M2M communication, but also over UHF radio bridges from locations where GSM signal is not available [8]. On the cloud IoT platform, Big Data from sensors can be conveniently processed and visualized as web applications and the platform can provide detailed forecasts, alerts and notifications of diseases, as well as treatment recommendations [9].

The paper is organized as follows. Section II presents a proposed Cloud IoT architecture for processing big data from M2M telemetry applications, while Section III presents research results and future applications. Finally, Section IV draws the conclusions.

II. M2M TELEMETRY AND CLOUD IOT ARCHITECTURE

A. M2M Architecture

In this section we present the architecture of the M2M telemetry system, as depicted in Fig. 1. The main requirements of the architecture are:

- extremely low power consumption;

- system designed for radio communication;
- extremely easy to install;
- fully remotely controlled;
- very long life time = very low TCO (Total Cost of Ownership);
- integrates GSM, GPRS, 3G, UHF;
- fully Web based.

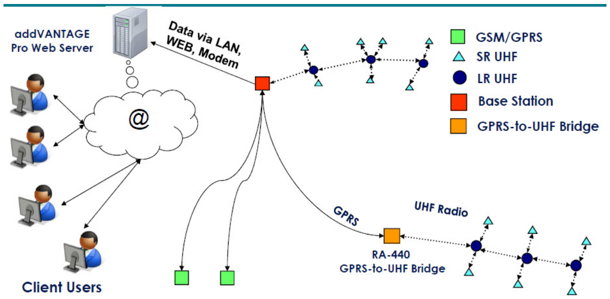

Fig. 1. M2M telemetry system architecture

The M2M telemetry software, which is based on a client/server architecture, collects data from one or several Adcon Telemetry Gateways (receivers) and makes it available for viewing or for specialized analysis. The server is that part of the software where all the actual processing takes place. It is responsible for downloading data from the Telemetry Gateway, storing data into the database, starting and stopping extensions, and servicing clients as they connect. The software and telemetry devices work together to form the telemetry system, which can be defined as a system that allows the user to:

- measure certain parameters over a predefined area;
- send those parameters over relatively large distances to a central point;
- process the parameters as needed for various applications such as agriculture, meteorology, irrigation control, water management, and environmental analysis.

The electrically converted parameters are first stored in the memory of a remote telemetry unit, or RTU. An RTU has its own intelligence in the form of a built-in microcontroller, which periodically performs several tasks, such as: interrogate the sensors, store the measured data, check the radio channel, check the local battery status, and so forth. It is part of a remote station, which consists of the RTU, its assembly parts, and its sensors. The RTU is equipped with a radio module or a GSM modem, which allows for real-time wireless communication with a base station.

The base station consists of a Telemetry Gateway (or receiver) and a user PC. The Gateway acts as a network controller—at regular intervals (typically 15 minutes, but this can be tuned) it requests data via radio or modem from the RTUs in the network.

The receiver stores the incoming data in its memory, thus allowing the receiver to supervise a large number of RTUs and keep their data for a period of time without the need to download the data to the PC. The number of controlled RTUs depends on the receiver type, and some receiver models can handle over 1000 units [10].

B. *Cloud IoT*

To implement the Cloud IoT architecture we use SlapOS [6], a decentralized Cloud Computing system based on the master-slave architecture. It can automate the deployment and configuration of applications in a heterogeneous environment for collecting data from IoT sensors. SlapOS supports IaaS, PaaS and SaaS applications.

SlapOS implements Infrastructure as a service (IaaS) by using distributed computers, providing a type of cloud computing in which a third-party provider hosts virtualized computing resources over the Internet. This is a form of cloud computing that provides virtualized computing resources over the Internet. In this IaaS model, a third-party provider hosts hardware, software, servers, storage and other infrastructure components on behalf of its users. IaaS providers also host users' applications and handle tasks including system maintenance, backup and resiliency planning [11].

Also, SlapOS implements Platform as a service (PaaS) by using the SlapOS master as a platform allowing customers to develop, run and manage Web applications without the complexity of building and maintaining the infrastructure typically associated with developing and launching an app. PaaS does not typically replace a business' entire infrastructure. Instead, a business relies on PaaS providers for key services, such as Java development or application hosting. This service can be delivered in two ways: as a public cloud service from a provider, where the consumer controls software deployment and configuration settings, and the provider provides the networks, servers, storage and other services to host the consumer's application; or as software installed in private data centers or public infrastructure as a service and managed by internal IT departments [12].

Furthermore, Software as a Service (SaaS) is implemented by using the software distribution model of SlapOS slave nodes. Applications are hosted by a vendor or service provider and made available to customers over a network, typically the Internet. SaaS is becoming an increasingly prevalent delivery model as underlying technologies that support Web services and service-oriented architecture (SOA) mature and new developmental approaches, such as Ajax, become popular. Meanwhile, broadband service has become increasingly available to support user access from more areas around the world. SaaS is closely related to the ASP (application service provider) and on demand computing software delivery models. IDC identifies two slightly different delivery models for SaaS. The hosted application management (hosted AM) model is similar to ASP: a provider hosts commercially available software for customers and delivers it over the Web. In the software on demand model, the provider gives customers network-based access to a single copy of an application created specifically for SaaS distribution [13].

C. *Big Data Processing*

Big Data is typically considered to be a data collection that has grown so large it can't be effectively or affordably managed (or exploited) using conventional data management tools: classic relational database management systems (RDBMS) or conventional search engines, depending on the task at hand. Today, classic RDBMS are complemented by a rich set of alternative DMS specifically designed to handle the volume, variety, velocity and variability of Big Data collections (the so-called "4Vs" of Big Data). These DMS include NoSQL, NewSQL and Search-based systems.

Exalead [14] is one of the leading search-based application platform provider to business and government. Exalead CloudView collects data from virtually any source, in any format, and transforms it into structured, pervasive, contextualized building blocks of business information that can be directly searched and queried, or used as the foundation for a new breed of lean, innovative information access applications. Furthermore, Exalead has several tools for big data processing, including:

- NoSQL systems that can support multiple activities, including exploratory and predictive analytics, ETL-style data transformation, and non-mission-critical OLTP (for example, managing long-duration or inter-organization transactions).
- NewSQL systems are relational databases designed to provide ACID-compliant, real-time OLTP and conventional SQL-based OLAP in Big Data environments.
- Big Data-capable search platforms naturally employ many of the same strategies and technologies as their NoSQL counterparts (distributed architectures, flexible data models, caching, etc.) – in fact, some would argue they are NoSQL solutions, but this classification would obscure their prime differentiator: natural language processing (NLP).

We use Exalead CloudView in our work to process the deluge of data that comes from the RTUs and turn them into graphical representations of the evolution of different parameters as can be seen in the next section, allowing different conclusions to be drawn.

III. Research Results and Future Applications

In order to collect the information from the RTUs we developed the following test platform as shown in Fig. 2. The usage of GSM/GPRS data transmission can be extended in areas where there is no coverage by using a UHF bridge operating in the fixed frequency range of 430 – 440 MHz connected to a gateway that has access to the Internet.

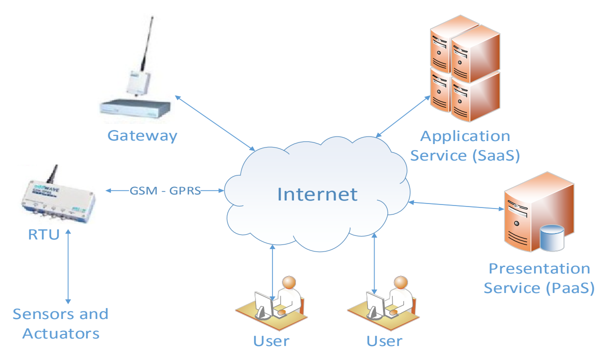

Fig. 2. General Architecture of the M2M Remote Telemetry System and Cloud IoT

The case study was done on 2 grape yards in Romania (Valea Călugarească and Cogealac) for the year 2014. What resulted was a survey of the winegrowing season 2014, as it was seen by the M2M telemetry server in cooperation with the monitoring station (on the mast, from top to down: GPRS Remote Telemetry Unit, rain gauge, solar panel, wind speed sensor, total radiation sensor (pyranometer), combined air relative humidity & temperature sensor, leaf wetness sensor), as seen in Fig. 3.

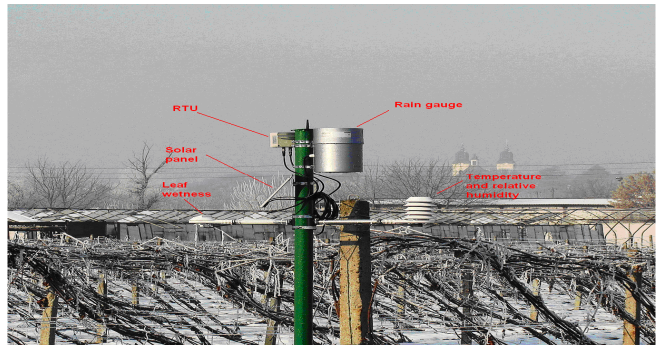

Fig. 3. General Structure of RTU and Sensors

The reference monitoring station was located in Cogealac (Romania, Constanta county), in the middle of a 150-hectare entirely drip-irrigated Cabernet Sauvignon vine.

The accumulated quantity of heat received by the culture was measured in accumulated degree-days, taking into calculation what exceeds + 10º C and a value of + 35º C for temperatures exceeding this upper limit, as seen on Fig. 4.

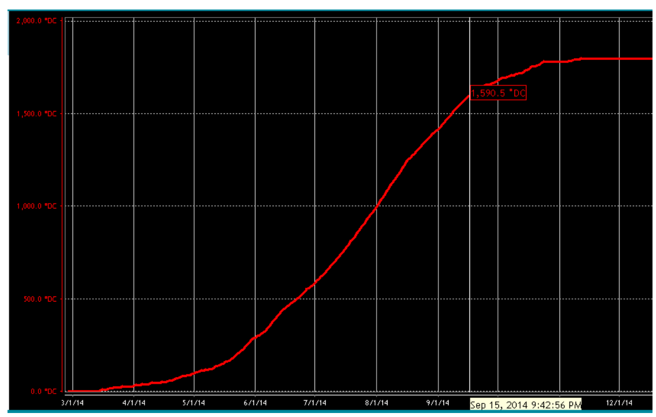

Fig. 4. Accumulated quantity of heat measured in 2014

The accumulated 1.600 - 1.700 degree-days, considered as necessary for e.g. Cabernet Sauvignon full maturation, were reached on 15.09.2014 and 01.10.2014 respectively, which was a bit later than in other years.

Another important parameter processed by the big data engine was the quantity of heat received daily by the culture, having a typical evolution, with about 426 degree-days accumulated during August for instance, as presented in Fig. 5.

This evolution of the heat along the season did justify the phenological phases featured in the window of Fig. 5 and taken into account in the disease management process presented in Fig. 6.

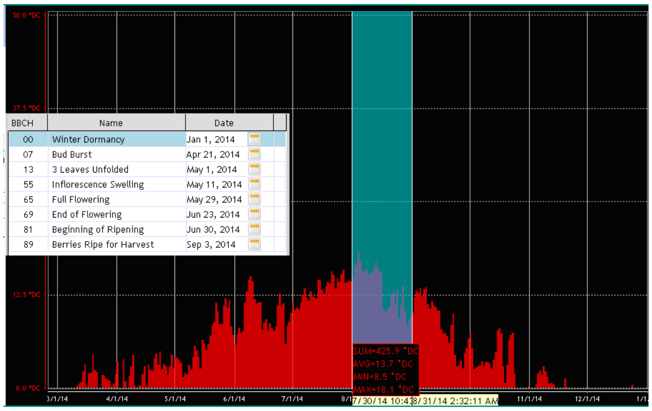

Fig. 5. Quantity of heat received daily (daily degree-days)

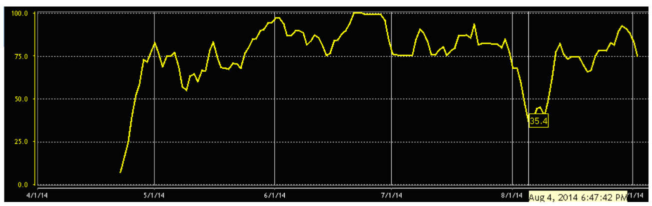

Fig. 6. Big data processing for visualizing disease management progress

Powdery mildew was the plant disease that represented for the crop a constant threat throughout the season. With a short relief only at the beginning of August, the powdery mildew pressure index has continuously situated itself at values like 75 and above, which represents a high risk of infection. The first treatment recommendation was issued by the system as early as 24.04.2014 and was followed by many other such alerts during the whole season.

For comparison, the evolution of powdery mildew pressure index in another season and another location is given in Fig. 7. Excepting a short lapse of time at the beginning of August, the pressure index has situated itself considerably under 75 during the whole season. It had, as a consequence, a relatively low number of treatment recommendations and treatments applied.

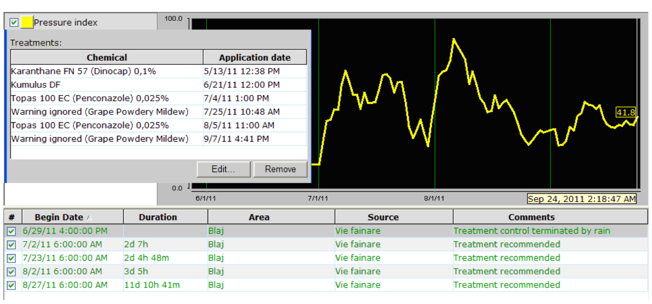

Fig. 7. Comparing disease evolution and treatments applied in another season (2011)

In support of the affirmation that the 2014 season was significantly dominated by the powdery mildew threat, the evolution of the powdery mildew pressure index and the treatments applied in another season (2011) and another location (Blaj) were visualized from the measured data stored in the big data processing platform.

As well as downy mildew, grape bunch rot also represented a very important issue during the 2014 season. The first spike of the bunch rot index appeared on 05.06.2014 and was only 1.123 high (not much above the 0.5 threshold for treatment recommendation of one day), as presented in Fig. 8. It was followed by only one other similar spike and treatment recommendation till the end of season.

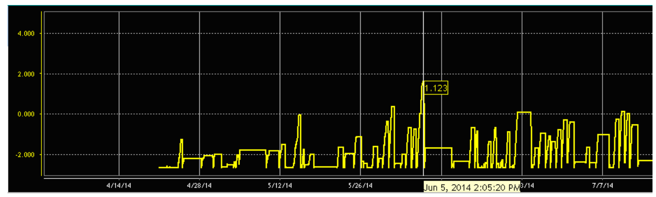

Fig. 8. Quantity of grape bunch rot in April-June period

Evapotranspiration (ETo) and precipitations were continuously monitored in order to apply irrigation water in exactly the quantity able to assure a future Cabernet Sauvignon wine of a very high quality. According to a Washington State University study, the optimal quantity of water to be received by the culture during a certain time interval equals the total evapotranspiration during the interval multiplied by the Crop Coefficient (KC). Along the season, this KC varies significantly as shown in Fig. 9. An important rise from 0.0 to about 0.8 takes place from May to mid-August and is followed by an abrupt decline during the weeks preceding harvest. Total evapotranspiration from 15.06.2014 to 15.07.2014 was 130.91 mm, while total precipitations were 33 mm. As the Crop Coefficient (KC) is, during the mentioned period, approximately 0.25, the optimum quantity of irrigation water amounts to 32.73 mm, which is exactly the quantity of water that the culture has received from rain (33 mm). Before 15.06.2014, the water need of the culture was much lower (see the KC diagram in Fig. 9), so that rain was more than sufficient to answer this need.

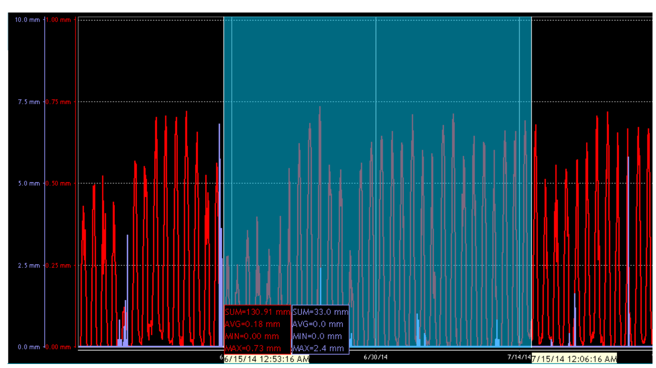

Fig. 9. Diagram with evolution of hourly evapotranspiration and precipitation intensity

From 15.07 to 15.08.2014, total evapotranspiration has amounted to 162.66 mm, while total precipitations were 30 mm only.

Considering an average Crop Coefficient KC of 0.65 along the mentioned lapse of time, a need of water of 105.73 mm results.

As this is much more than the 30 mm provided by the rain, it was necessary to accordingly use the drip irrigation installation that entirely covers the monitored vineyard. Irrigations were completely stopped about two weeks before harvest.

Furthermore, the proposed system can be extended for measuring water and groundwater level, including soil moisture, as well as other environmental monitoring for air, soil and water quality.

IV. CONCLUSION

In this paper, we presented a survey of the measurement results for the winegrowing season 2014, as it was seen by the M2M remote telemetry stations (RTUs) in cooperation with a big data processing platform and different sensors: rain gauge, solar panel, wind speed sensor, total radiation sensor (pyranometer), combined air relative humidity & temperature sensor, leaf wetness sensor.

The case study was done on 2 grape yards in Romania. Besides wine grape, disease management can be as well performed for different other crops.and many other crops.

The paper demonstrates the use of recent technologies such as M2M remote telemetry, Cloud IoT systems and Big Data processing in order to implement disease prediction and alerting application for viticulture.

As future work we envision to adapt the proposed system for viticulture telemetry to other applications besides agriculture, for example precision farming and meteorology.

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REFERENCES

[1] F. Bonomi, R. Milito, J. Zhu, and S. Addepalli. "Fog computing and its role in the internet of things." In Proceedings of the first edition of the MCC workshop on Mobile cloud computing, pp. 13-16. ACM, 2012.

[2] O. Fratu, S. Halunga, R. Crăciunescu, A. Vulpe, “Instrumental IoT - from Environmental Monitoring to Cosmic Ray Detection,” Telecommunications Forum (TELFOR), pp. 17-22, 2014.

[3] G. Suciu, V. Suciu, S. Halunga, O. Fratu, B. Anggorojati “Cloud Systems and Big Data Processing for Environmental Telemetry. A Case Study for Applications in Viticulture”, International Conference on Applied and Theoretical Electricity (ICATE 2014), pp. 1-4, 2014.

[4] A Ochian, G Suciu, O FRATU, C. Voicu, V Suciu, „An overview of cloud middleware services for interconnection of healthcare platforms”, Proceedings of 10th IEEE International Conference on Communications (COMM), 2014, pp. 1-4, 2014.

[5] J. Nabrzyski, C. Liu, C. Vardeman, S. Gesing, and M. Budhatoki. "Agriculture Data for All-Integrated Tools for Agriculture Data Integration, Analytics, and Sharing." In Big Data (BigData Congress), 2014 IEEE International Congress on, pp. 774-775. IEEE, 2014.

[6] W. Saad, H. Abbes, M. Jemni, and C. Cérin. "Designing and implementing a cloud-hosted saas for data movement and sharing with slapos." International Journal of Big Data Intelligence 1, no. 1, pp. 18-35, 2014.

[7] A. Ochian, G. Suciu, O. Fratu, and V. Suciu. "Big data search for environmental telemetry." In Communications and Networking (BlackSeaCom), 2014 IEEE International Black Sea Conference on, pp. 182-184. IEEE, 2014.

[8] J.A. Jiang, C.L. Tseng, F.M. Lu, E.C. Yang, Z.S. Wu, C.P. Chen, S.H. Lin, K.C. Lin, and C.S. Liao, “A GSM-based remote wireless automatic monitoring system for field information: A case study for ecological monitoring of the oriental fruit fly, Bactrocera dorsalis (Hendel),” Computers and Electronics in Agriculture vol. 62, Issue 2, pp. 243–259, 2008.

[9] G. Suciu, S. Halunga, O. Fratu, A. Vasilescu, and V. Suciu. "Study for renewable energy telemetry using a decentralized cloud M2M system." In IEEE Wireless Personal Multimedia Communications (WPMC), 16th International Symposium on, pp. 1-5, 2013.

[10] S. Peukert, B. A. Griffith, P. J. Murray, C. JA. Macleod, and R. E. Brazier. "Intensive Management in Grasslands Causes Diffuse Water Pollution at the Farm Scale." Journal of environmental quality 43, no. 6, pp. 2009-2023, 2014.

[11] C. Jiang, J. Wan, C. Cérin, P. Gianessi, and Y. Ngoko. "Towards Energy Efficient Allocation for Applications in Volunteer Cloud." In Parallel & Distributed Processing Symposium Workshops (IPDPSW), 2014 IEEE International, pp. 1516-1525, 2014.

[12] F. Fowley, C. Pahl, and L. Zhang. "A comparison framework and review of service brokerage solutions for cloud architectures." In Service-Oriented Computing–ICSOC 2013 Workshops, pp. 137-149. Springer International Publishing, 2014.

[13] C. Butcă, G. Suciu, A. Ochian, O. FRATU, S. Halunga, „Wearable sensors and cloud platform for monitoring environmental parameters in e-health applications”, 11th International Symposium on Electronics and Telecommunications, pp 1-4, Timişoara, Romania, 14-15 November 2014

[14] EXALEAD – Dassault Systemes, http://www.3ds.com/products-services/exalead