Towards an SOA Architectural Model for AAL-Paas

Design and Implimentation Challenges

Amina El murabet
Computer Engineering Department
National school of Applied Science of Tetuan
Tetuan, Morocco

Abdellah Touhafi
Electronics-ICT Department
Vrije Universiteit Brussel
Brussel, Belguim

Anouar Abtoy
Computer Engineering Departement
National school of Applied Science of Tetuan
Tetuan, Morocco

Abderahim Tahiri
Computer Engineering Departement
National school of Applied Science of Tetuan
Tetuan, Morocco

***Abstract*—Ambient Assisted Living (AAL) systems main purpose is to improve the quality of life of special groups of people, including the elderly and people with physical disabilities. Driven by the critical ongoing changes in all modern, industrialized countries, there is a huge interest in IT-based equipment and services these days, to facilitate daily tasks and extend the independency time for these groups. Thence, AAL systems can benefit from the huge advances of both intelligent systems and communication technologies as promising growing research fields. The implementation of such complicated yet vital system should be established on solid bases relying on a standard architecture to satisfy and respond to the needs of heterogeneous stakeholders. This article proposes a Service Oriented Architecture model for Ambient Assisted Living Platform as a Service based on Wireless Sensors Network, it starts by presenting a classification of ambient assisted living services. Secondly, it describes some user and environmental challenges that have an impact on the service qualities. The discussion of architectural trends for AAL systems is included, and the description of challenges in designing and implementing of an effective one. Finally, this paper introduces a new vision of prototypical AAL systems architecture.**

***Keywords*—Ambient Assisted Living (AAL); Ambient Assisted Living Platform as a Service (AAL-PaaS); Service Oriented Architecture (SOA); Wireless Sensors Network (WSN)**

I. INTRODUCTION

The field of AAL (Ambient Assisted Living) has taken a favorable intention between the major research fields in intelligent systems and communication technologies. AAL is taking benefits of all information technology developments, in order to denote solutions capable of improving and facilitating the life of the growing elderly population and people with physical disabilities [1]. These systems aim to help them in their daily affaires, to extend independency periods and reduce the time of needing caregivers.

The majority of the existing personal emergency response systems use emergency push buttons that can be inconvenient in critical emergencies, such as falling or unconsciousness [2]. This provokes the need of systems that do not require the involvements of the user. Therefore, there is a significant trend to AAL systems, based on "Auto-Sensing" (Using Wireless Sensors Network and other sensing equipment) and "Auto-Acting" (Using Actuators such as alarms, phone calls, robots, etc.) which should be able to scan the local environment, obtain useful data, process this data and act according to the assembled knowledge built out of treating the collected information.

Several AAL systems proposals based their performances on different types of sensors to measure weight, blood pressure, glucose, oxygen, temperature, location, and position are available nowadays. Each system is deployed using a communication technology such as Bluetooth, USB, and Ethernet, among others [2]. In addition, the most used interfaces are developed for tablets and smartphones, although applications for health systems or set-top boxes can be found. Generally, these kinds of systems are focused on solving basic issues in services such as healthcare provision, disease management, diet and fitness, personal health records, and person location.

AAL Systems need to be affordable, considering that affording a caregiver is not an available option of all stakeholders. They also should depend on the special needs of each user because of the enormous variation of demands between elderly people and people with physical disabilities, such as the visually and hearing impaired (babies and children are also considered as a specified group of stakeholders). Having a clear classification of living assistance services is a necessity to determine the target stakeholders, and establish a model of the particular environment, to be able to draw a clear vision of the architectural model for such systems.

The heterogeneity of stakeholders gave a strong motivation for engineers to aim for a standard architecture to stand AAL systems on, so they can be easily adapted and maintained, giving the fact that AAL systems rely on various technologies and mismatched equipment.

In order to clarify an understanding of the main problem, and overall software solution and integration approaches, this paper 1) describes the classification of ambient assisted living services; 2) present some user and environmental challenges

for AAL systems; 3) briefly discusses some architectural trends; 4) proposes an SOA based model for an AAL-PaaS (Ambient Assisted Living Platform as a Service) established on WSN (Wireless Sensors Network).

II. Categories of Ambient Assistance Living Services

To build a stable, solid and consolidated ambient assistance living system, the main concern is to determine the living assistance domains and classifying them, in order to include every assistive service that may ease daily life in all aspects. The "classification scheme" in Fig. 1 structures these domains into nine classes:

The first category is divided into "indoor" and "outdoor" living assistance. Indoor assistance services are the ones presented in a determined space: in apartments, homes, cars, hospitals, and elderly care homes. They can be built upon a well-known hardware/software installation in the specified location, thereby providing a stable environment.

Outdoor assistance services aim to support persons during activities outside their homes. It is also divided into two classes: 1) firstly at work: to allow an active and productive aging for elderly people and suitable environment for those with physical disabilities in a defined workplace and a stable environment; 2) in community: while shopping, transportation, and during other social activities. These services have to face with highly unstable environmental conditions such as special equipment and technical installations [3].

Other dimensions can be used to specify the type of service provided. According to Fig. 1, the attention is given to three types of services:

1) "*Emergency treatment*" presents services that aim to predict and react toward critical conditions that might result in an emergency.

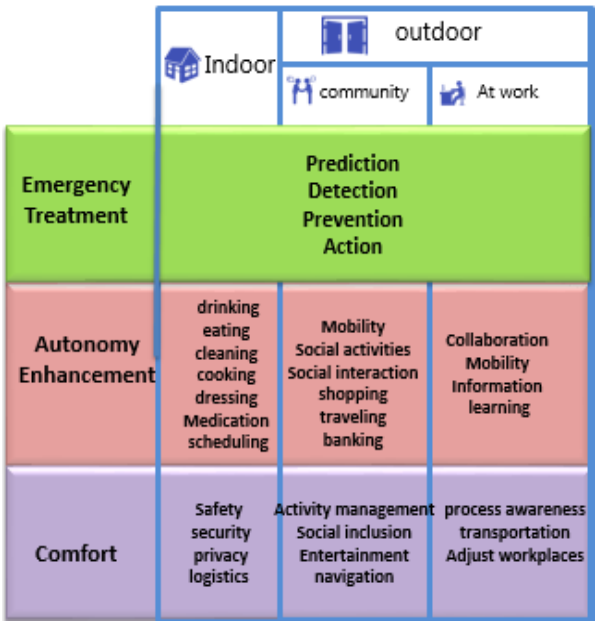

Fig. 1. Categories of AAL services.

2) "*Autonomy enhancement*" services increase the independence of the assisted persons.

3) "*Comfort*": These services ease the daily life but are not necessarily required. In addition, they cover all areas that do not fall into the other presented categories.

Stakeholders have different capabilities and needs which can develop over time, these needs can change and determine the categories and types of services. Therefore, this can change the presented classification.

Moreover, "emergency treatments" are considered as the main core of any AAL service portfolio, due to the increasing of emergencies coupled with the decreasing capability to deal with such circumstances.

III. User and Environmental Challenges and System Requirements for AAL-PaaS

A. User and Environmental Challenges

The main goal of AAL systems is to facilitate the regular basic tasks for the stakeholders within a determined environment or space. Consequently, to help designing such systems many challenges should be taken in consideration, evaluated and treated, in order to have a consolidated and stable system. These challenges might be separated into two groups, user related and environment related ones.

Some of the main conceptual confrontations of the system are: the divergent of capabilities, needs and habits that vary from one stockholder to another, elderly people have particular demands distinct from users with physical disabilities. This diversity is also time related. Some of the individuals have an incremented demand for regular assistance due to the changing conditions in each particular situation. Moreover, users usually are not friendly to the technical problems, they do not show tolerance to the technical complications, and cannot afford maintenance every now and on. The assisted person should also be able to control the system and not vice versa. Although the system should share the user data with data centers and institutions such as hospitals, involved organizations, etc. It must preserve privacy and secure information and data of the relevant user. Hence, the system should act and react toward the user; it should also maintain his safety and conserve a highly protected space [4]. The system should also be fair in terms of space, lifetime and budget. It has to be highly productive in spite of the limited, up-to-date resources.

The user interface provokes many other challenges to the system designer. Numerous details are fundamental to be respected while the perception of the system overview, and the attention should be focused on: Human-computer interaction, where the designer is asked to take advantage of the interactive technologies, to ease behaving toward the system, the communication between the user and the system should be optimized and effective in an ergonomic way. Usability and accessibility to the system are both critical claims of all stakeholders [5]. Finally, the designer should take in consideration the information architecture and the saving politics to be followed in order to structure and organize the

data within the system itself and with other connected devices, data centers, applications, etc. to be handy for the user display.

B. System Requirements

To help structuring a solid, reliable AAL system many requirements and major developments should be proceeding in different fields of research, among them:

- **Sensing technologies**, in AAL applications, there is a need of intelligent and innovative sensors "smart sensors" capable of collecting data, such as measuring physical and electrical quantities, miniaturized, made of low cost materials, able of taking place in anything, anywhere, anytime (home, outdoors, vehicles, public places, etc.) and qualified to perform some processing on the node level in the network.
- **Reasoning**, which is a core duty of AAL systems due to the conclusion of knowledge, resulted from processing data collected by sensors and converting it into useful information to learn from it. This should allow not only the recognition of activities, such as motions and the detection of emergencies by the use of evolutionary models; but also to predict and anticipate possible status and provide support in decision-making.
- **Event definition**, where there is a need to adapt an event driven architecture to promote the production, detection and consumption of, and reaction to events which signify a change in states. The design of AAL-PaaS should be able to transmit events among loosely coupled software components** and services, this should put up with the use of cross-platform runtime environments such as Node.js.
- **Acting**, systems and services, which proactively (based on the knowledge resulted from the reasoning) act to prevent, compensate, support and provide well-being and increase the independence of senior citizens.

Finally, some primary conditions are not to be ignored and should be respected such as affordability, usability, suitability, dependability, adaptivity, extensibility, resource efficiency and heterogeneity that should be the main characteristics of such a system.

By respecting all of the quoted earlier standards, the main work can be driven toward a comprehensive and complete architectural model vision of the desirable system to implement.

IV. Architectural Trends for AAL Systems

The architecture of a system gives an overview of the desirable system to be implemented; it is the central design that describes quality requirements such as cost, dependability, performance, etc. of the overall solution. It plays a pivotal role for the quality achievement. Furthermore, it comprises: software elements, the externally visible properties of those elements and the relationships among them. For the time been there is no commonly accepted architecture for AAL systems, different approaches are followed to meet the functional and quality requirements in the present and developing systems [6].

AAL systems are systems which provide assistance that has two facets: 1) an easy access for the assisted person to autonomy enhancement or comfort services, home control, social interaction, etc.; 2) the anticipatory assistance of the assisted person with proactive emergency treatment such as automatic alarms, home automation, notifications, etc. for anticipatory systems the rendered functionality as be: Awareness or Presence. The system should also be kind of closed loop controller that senses its environment and especially the persons living therein and influences the environment with its actuators.

Awareness of the system can be decomposed in three functional blocks: Sensing/perception/identification while the presence is decomposed into planning/controlling/acting. This decomposition is clear in the following Fig. 2 presentation in which the system should exchange data with the surrounded environment and the target stakeholder while facing the mentioned challenges and respecting the required principals.

A common style for ambient intelligence systems are data processing pipeline or signal [3] which made communication fluent between the elements of the system.

Several ways are conceivable to realize the conceptual decomposition of functionality in the system physically.

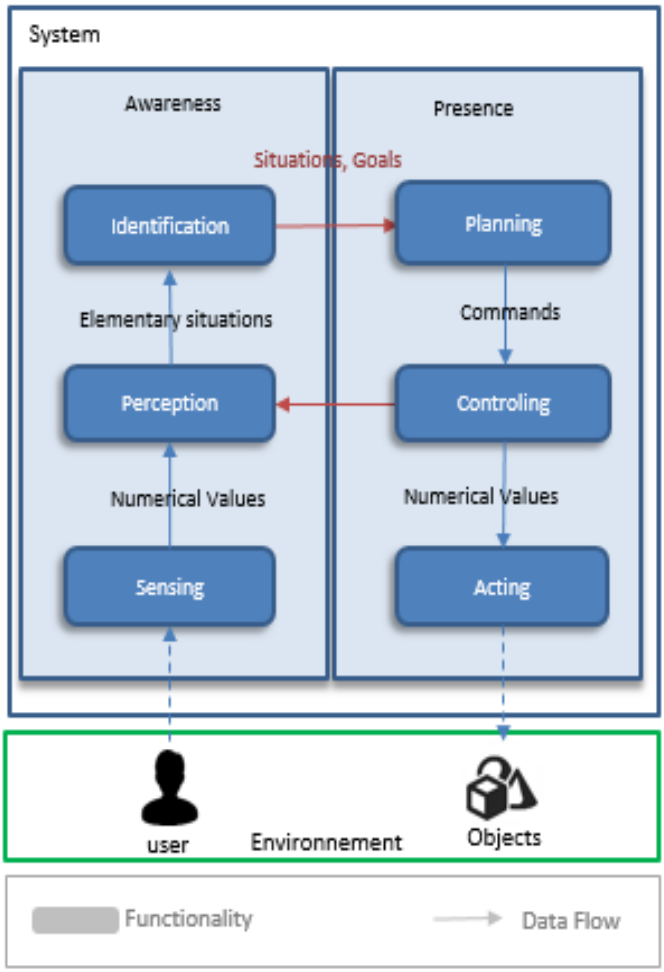

Fig. 2. Functional blocks of AAL system [3].

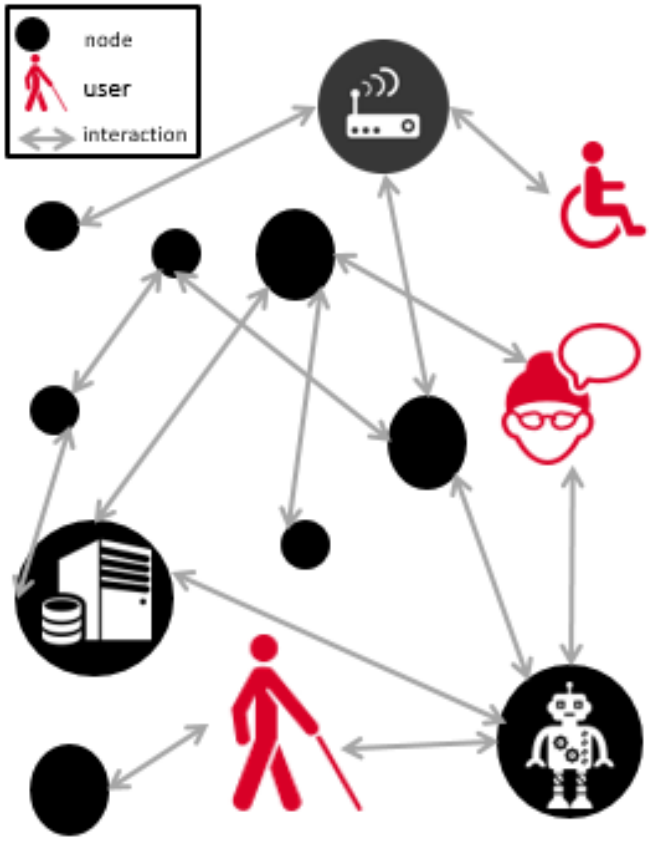

Fig. 3. Physical perspective of AAL System.

From a physical perspective: the topology of the AAL system will consist of tens to hundreds of different interacting nodes [using the sensors] ranging from tiny sensor nodes [with low computational power] up to powerful machines, which are interacting together.

Fig. 3 presents generally a physical overview of an AAL system with its major elements, the observation drive us to the fact that an AAL system should rely on using several nodes presenting the sensors, actuators and data servers in a direct interaction between one another and toward the user.

V. SOA Model for an AAL-PaaS Based on WSN

An architecture model is a division of the functionality together with data flow between the pieces [5], [7]. It is an abstract representation of a system expressed primarily using software components interacting via connectors.

In this part of the paper we are trying to implement an architectural model of an AAL-PaaS system based on WSN (Wireless sensors Network) using the SOA (Service Oriented Architecture) as a promising architectural style in the AAL domain and the revolutionary technologies such as "Cloud" and "Node.js" as a successful development technology to build data-intensive applications [8].

When implementing such an AAL system, all the above-mentioned features should be taken in consideration. On one hand, sensors should be non-invasive systems they can be embedded in clothes, shoes, watches, or glasses [9], [10]. Thus, people will not mind wearing them. If sensors were visible, users could be discriminated against by other persons [4]. In addition, sensors must have wireless communication interfaces to let people move away from their homes. Smart phones, actuators, computer hardware, computer networks, software applications, should be interconnected together to collect and exchange data and provide services in an Ambient Assisted environment. The sensors and the actuators are connected with the AAL applications to send medical data to the health monitoring systems. Sensors should not be the only source of data; the system should examine the historical information of the stockholder [11] taking from other data sources such as Hospitals data servers, should also relay on existing shared applications and services through the "Cloud".

After collecting data, the system should be able to integrate the information, analyze it, treat it and transform it into a useful knowledge, in which the system relies on to provoke actions. Service Oriented Architecture is widely regarded as the software paradigm of the next decade, especially in the field of information systems [12], [13]. A central quality of SOA is to support an easy exchange of implementation and orchestration of new functionality (which contributes positively to the modifiability and extensibility of the systems) by separating the contract (service) from the implementation (component), in this way; this architecture increases the reusability of the service and components.

Using SOA architecture means dividing the system into clear and reusable services, this approach gave us the opportunity also to use existing services and adapting them into the newly designed system. In this case, there is a necessity to assure interoperability and ease the communication between these services. In this determination, the system should obey to some standards: to guarantee communication without particular concern, to give services the possibility to evolve independently without the risk of breaking predefined communication.

In SOA architectures, the process choreographer has been chosen as a useful architecture model used for designing and implementing communication between mutually interacting software applications and services. It provides routing, transformation, mediation, etc. It presents the communication bus between the different services and processes of the proposed architectural model.

The design of AAL-PaaS should be able to transmit events among loosely coupled software components (in which each of its components makes use of, little or no knowledge of other separate components) and services, this should put up with the use of cross-platform runtime environments such as "Node.js" which has an event-driven architecture capable of asynchronous I/O [Input /Output] [14]. These design choices meant to optimize throughput and scalability in Web applications with many input/output operations, as well as for real-time Web applications.

In Fig. 4, we propose an architectural model based on the logical view of the software architectural design describing how the system is structured.

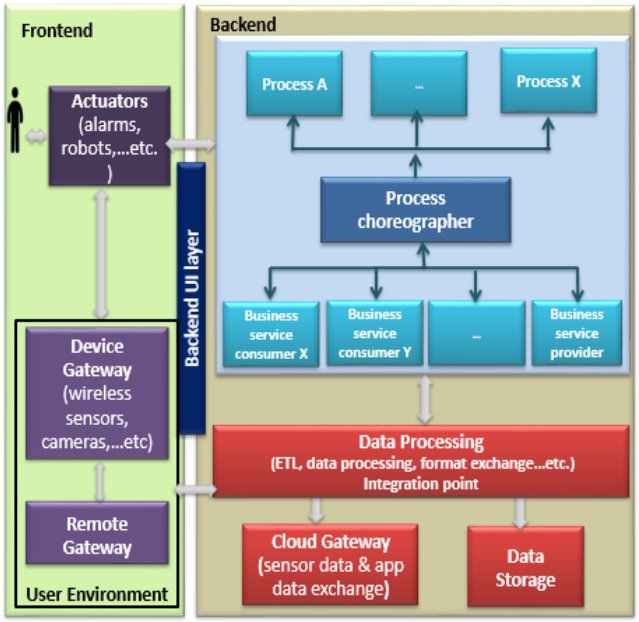

Fig. 4. AAL architectural model based on SOA.

In our approach, the implementation of the architectural model is based on SOA. The situational and environmental information about people, places and things is collected and stored into the system by means of a sensing environment installed in the indoor environment including: wireless sensors, cameras, accelerometers and movement detectors, Audio/Video perceptual components, etc. which are figured by **Device Gateway** and **Remote Gateway.** Other **Data Storages** used to gather information about historical states of illnesses and health care parameters. These data and information are processed together using **Data Processing** elements such as ETL (Extract, Transform, Load) [15] software in an integration point to gather, extract, transform and unify the collected data in order to pull knowledge from it.

Services in the architectural model are connected in order to coordinate the exchange between the **business services consumers** and **services providers**, the process choreographer to assure coherent between services and defines the appropriate processes to be launched by the defined actuator, which are equipment capable of performing an action towards the user or his environment. Their actions are stimulated based on the knowledge resulted from processing the collected data. These actuators may be Robots, alarms, etc.

VI. CONCLUSION

In order to introduce our overview of an AAL system architecture based on SOA and EDA (Event Driven Architecture), a study of the classification of ambient assisted living services was made. From the research that has been carried out, we determined the major user and environmental challenges, to be taken into consideration while designing such systems. Furthermore, a description of the major technical requirements to build a solid, reliable system has been clarified. Finally, an illustration of our vision has been presented using a model scheme where the major layer compositions of a firm AAL system are included. The next approach is focalized on prefunding the research in each of the architectural components and examining particular integration elements distinctively data integration and service integration components in the interest of having a harmonious, homogeneous system architecture. Future work will involve a study on the AAL data collection and integration, considering the bigness of the data, the variety of sources and the nature of the information provided.

REFERENCES

[1] P. Rashidi and A. Mihailidis, “A Survey on Ambient-Assisted Living Tools for Older Adults,” in IEEE Journal of Biomedical and Health Informatics, vol. 17, no. 3, pp. 579-590, May 2013.

[2] J. Lloret, A. Canovas, S. Sendra, et L. Parra, “A smart communication architecture for ambient assisted living”, IEEE Communications Magazine, vol. 53, no 1, p. 26-33, janv. 2015.

[3] M. Becker, “Software Architecture Trends and Promising Technology for Ambient Assisted Living Systems”, Dagstuhl Seminar Proceedings, 2008.

[4] P. Koleva, K. Tonchev, G. Balabanov, A. Manolova, et V. Poulkov, “Challenges in designing and implementation of an effective Ambient Assisted Living system”, in 2015 12th International Conference on Telecommunication in Modern Satellite, Cable and Broadcasting Services (TELSIKS), 2015, p. 305‑308.

[5] Röcker, C. (2011). Designing Ambient Assisted Living Applications: An Overview of State-of-the-Art Implementation Concepts. In: X. Chunxiao (Ed.): Modeling, Simulation and Control, Proceedings of the International Conference on Information and Digital Engineering (ICIDE 2011), September 16- 18, Singapore, pp. 167 - 172.

[6] M. Klein, A. Schmidt, and R. Lauer, “Ontology-centred design of an ambient middleware for assisted living: The case of soprano,” in Proc. Annu. German Conf. Artif. Intell., 2007.

[7] P. Wolf, A. Schmidt, J. P. Otte, M. Klein, S. Rollwage, B. König-ries, T. Dettborn, et A. Gabdulkhakova, openAAL 1- the open source middleware for ambient-assisted living (AAL). 2010.

[8] K. Lei, Y. Ma, and Z. Tan, “Performance Comparison and Evaluation of Web Development Technologies in PHP, Python, and Node.js,” in 2014 IEEE 17th International Conference on Computational Science and Engineering, 2014, pp. 661–668.

[9] C. S. Raghavendra, K. M. Sivalingam, and T. Znati, Wireless Sensor Networks. Springer, 2006.

[10] S. Kurt, H. U. Yildiz, M. Yigit, B. Tavli, and V. C. Gungor, “Packet Size Optimization in Wireless Sensor Networks for Smart Grid Applications,” IEEE Transactions on Industrial Electronics, vol. 64, no. 3, pp. 2392–2401, Mar. 2017.

[11] K. Häyrinen, K. Saranto, and P. Nykänen, “Definition, structure, content, use and impacts of electronic health records: A review of the research literature,” International Journal of Medical Informatics, vol. 77, no. 5, pp. 291–304, May 2008.

[12] H. Fouad, A. Gilliam, S. Guleyupoglu, and S. M. Russell, “Automated evaluation of service oriented architecture systems: a case study,” 2017, vol. 10207, p. 102070J–102070J–8.

[13] Dhara, Kamala Manasa; Dharmala, Madhuri; and Sharma, Chamma Krishan, “A Survey Paper on Service Oriented Architecture Approach and Modern Web Services” (2015). *All Capstone Projects*. 157

[14] H.-K. Ra, H. J. Yoon, A. Salekin, J.-H. Lee, J. A. Stankovic, and S. H. Son, “Software Architecture for Efeiciently Designing Cloud Applications Using Node.Js,” in Proceedings of the 14th Annual International Conference on Mobile Systems, Applications, and Services Companion, New York, NY, USA, 2016, pp. 72–72.

[15] M. J. Denney, D. M. Long, M. G. Armistead, J. L. Anderson, and B. N. Conway, “Validating the extract, transform, load process used to populate a large clinical research database,” International Journal of Medical Informatics, vol. 94, pp. 271–274, Oct. 2016.