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Inspiring a Fractal Approach in Higher Education Institutes' Information Systems in Kurdistan: A Review

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The structure of student registration systems in higher education institutes in the Kurdistan Region needs more flexibility to overcome system requirements in a quick manner. This is due to the increasing demand of students whom would like to complete their study and also due to the increasing the number of universities (i.e. public and private). Also, the requirements of the aforementioned systems require accurately circulating and updated productive information among system units. Hence, this paper seeks to incorporate fractal features in higher education institute systems. Fractal features can provide best solutions for the aforementioned requirements. Therefore, this paper reviews several works that present different fractal-based methods for improving the structure of information systems in different administration sectors. Indeed, a fractal-based method to connect Kurdistan Higher Education Institutes Systems (FKHEIS) is proposed in order to improve the cooperation among system units and provide a more flexible system.

Keywords: *Fractal Approach, Information System, Flexibility and Adaptability, Cooperative Educational Institutes' Information System.*

Introduction

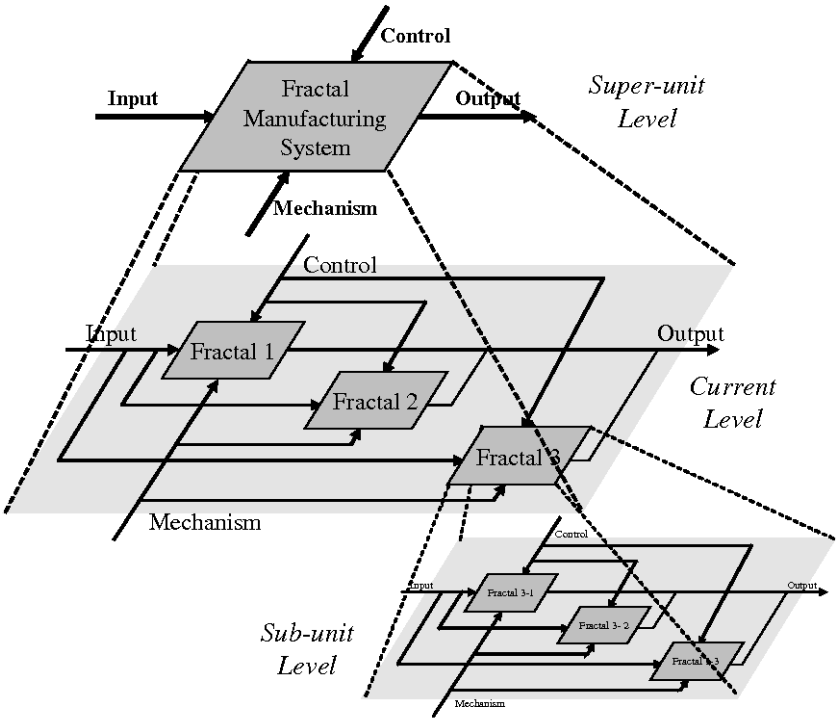
Nowadays, application of information systems (IS) has become an essential aspect in different fields which consists of autonomous units. According to Asnina et al.(2008) each unit can operate as an IS independently but at the same time can operate with other units collaboratively.

The improvement of information in terms of its capabilities adaption is a crucial task because this preserves the external environment of the system (Marite Kirikova, 2009a). All the changes need to be executed in the many systems that need long-term functionality, such as data structure, access rights, functional processes and information (Marite Kirikova, 2009b). Therefore, operations between the student affairs' units of the Ministry of Higher Education and Student Registration in the Kurdistan Region have to cooperate in a flexible manner (Abdulazeez, Zeebaree, & Sadeeq, 2018). The applications of utilising the fractal methods to construct the flexible and cooperative models are presented in this study. Also, the properties of fractal methods are presented seeking to investigate whether these methods are able to adapt themselves with building the cooperative educational information system in which the main idea of this adaptation is to make the units of educational information system more flexible, cooperative and adaptable which is able to consider each unit as a fractal. Satisfying these capabilities will make an educational information system more flexible to changes required due to internal and/or external system requirements.

The Fractal Concept

The fractal concept can be defined as a shape made of parts where each part is similar to the whole in some way (Ahmed, 2013). The term fractal originally came from the Latin word fractus which means fractured or something broken. The introduction of the fractal concept was first used by the French mathematician, physical scientist and biologist Benoit Mandelbrot to label geometric objects where one part or whole parts were the same in some way and that had similar features at all level of magnification, such as mountains, coastlines, lasers and waves (Bodunkova & Chernaya, 2012). Hence, the complex system that was generated over the recursion and integration of simple units can be organised by using fractal theory (Hongzhao, Dongxu, Yanwei, & Ying, 2005), (Zeebaree, Haron, Abdulazeez, & Zebari, 2019), (Warnecke & Hüser) used fractal theory to describe, first the process and structures of a system in the manufacturing environment, and second the fractal geometry features were applied to modelling the behaviour of the manufacturing system. This framework of Warnecke's became the introduction and keystone of the fractal factory concept (Poenaru, Dobrescu, & Merezeanu, 2017). Ryu (2003) presents two significant features, the first is called self-organisation and the second is named self-similarity in which both features avail from the conceptual framework of Warnecke's theory. Both features were utilised in modelling the low-level unit of organisation in the fractal factory. Later, several works were conducted by using Warnecke's fractal factory with the aim of developing a new framework for a manufacturing system that is capable of adaptation in the multi-agent systems technology, see work of Monostori, et al (2006). In addition, the principles of Warnecke's fractal theory was extended in a system called fractal-based systems where the connection of a system' units within the distribution manufacturing system is obtained, see Figure 1(2003).

Figure 1. Multi unit level of the fractal manufacturing system, Ryu(2003)



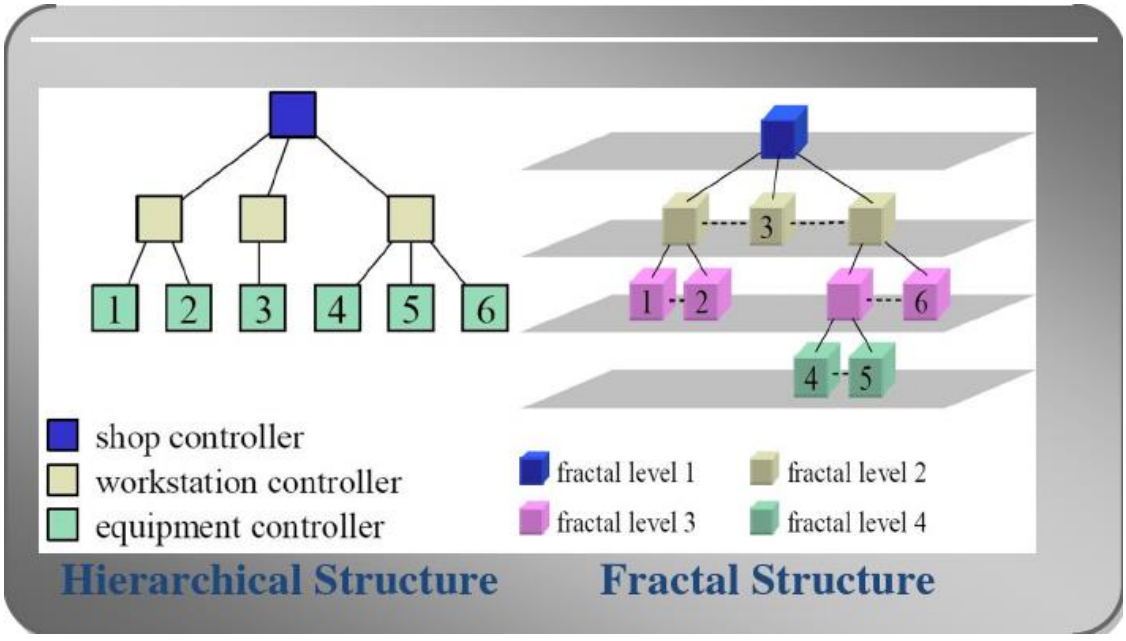
The fractal company was introduced which has significant differences compared with the traditional system (i.e. hierarchical systems) in terms of data availability, goal orientation, component relationship of the system, adaptability, flexibility and relationships with external partners as well as the relationship with stakeholders (see table 1). In the most aforementioned differences, the fractal company has an advantage over the traditional system (Bodunkova & Chernaya, 2012).

Table 1. The Comparison Between the Fractal and Hierarchical Structures

	Hierarchical structure	**Fractal structure**
Hierarchy	Structured once only, at a specific point in time	Subject to a constant process of change (dynamic structuring)
Component relationship	Administrative higher unit and passive lower units	Coordinative higher fractal and active lower fractals
Job processing	Work according to specified objectives	Work through the goal-formation process
Unit function	Controllers at the same level in the hierarchy have similar functions	Every fractals have same functional modules
Adaptability	Suitable for a steady environment	Suitable for a turbulent environment
Flexibility	Not flexible	Flexible

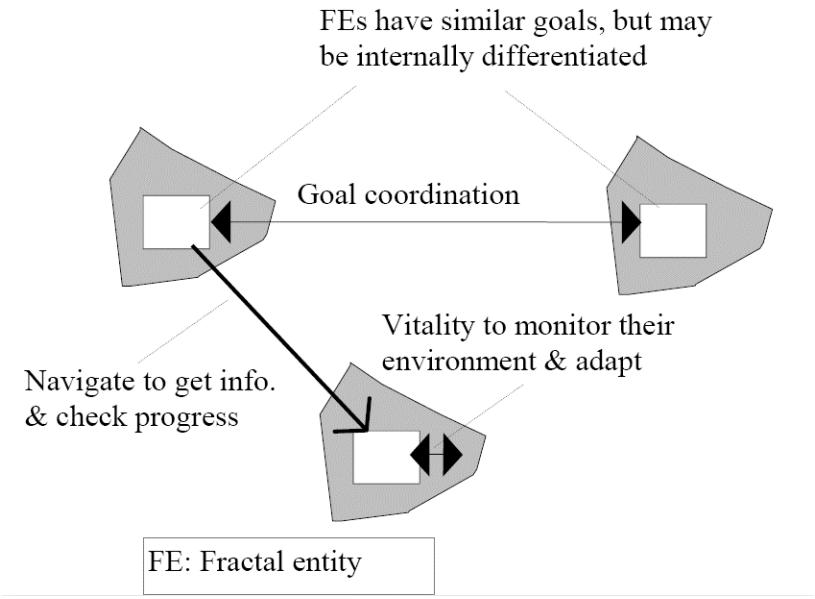
Ryu (2003) illustrated the difference between fractal and traditional structures in terms of presenting the relationships among the fractal levels and administrative control units respectively, see Figure 2.

Figure 2. Fractal and Hierarchical Structures Comparison, Ryu(2003)



Hence, the fractal company can be recognised as an open system that consists of autonomous functioning units as well as being an integral part of a fractal by itself (Bodunkova & Chernaya, 2012). The conceptual idea of the fractal method is utilised to remedy the lack of flexibility in a system considering the internal and external factors, and also it used to decrease the complexity of the structure of the organisational system via increasing the expandability and optimisation (Xiaohua, Wei, Yanming, & Shixiong, 2006). Tharumarajah et al.(1998) and (Warnecke & Hüser) proposed the ideal concept of a fractal-based system that started from the bottom (i.e. low level) to the top (i.e. high level) of the structure system. This means the higher level fractal knows its responsibility will be limited to fulfil those responsibilities that are unable to be managed by the lower order fractals. This action guarantees the teamwork among the fractal units where the powers and abilities of the system will be distributed in a reasonable manner. This type of distributed system has several features that can only reflect theory, for instance navigation and aim orientation, self-organisation and similarity as well as vitality and dynamic. Tharumarajah et al. (1998) pointed out that each of the aforementioned properties during the operation stage perform a distinct and clear function within the fractal system and that the cooperation and adaptation among the factory fractals can occur in a smooth way. See Figure 3 for more details about the coherent relationship among these features. Based on the above, this approach has become popular and continues to be used in the improvement of designing information systems in different sectors (Ahmed, 2013; Ahmed & Yasin, 2012).

Figure 3. Shows Fractal Entities Operation, Tharumarajah (Amini, Ahmad, & Swamy)



Fractal Theory Features

The fractal features are detailed in the following sub-sections, which are described in order to investigate the objectives of this research:

Self-Similarity

One of the major properties of a fractal is its self-similarity. According to Sprock (2018) the self-similarity systems are exactly or approximately similar to a part of itself. It is the nature of fractal structures that the interlaced parts of a system are shaped in the same pattern of the whole (Zhao, Qin, Yao, & Yan, 2014). One fractal unit is similar to another fractal but with a different internal structure (Attar[1] & Kulkarni, 2014). The units of a fractal system consist of a set of similar components and these components decrease the complexity of a system design and improve maintainability of the system (Sprock, 2018). Self-similarity provides flexibility in any system; however, having only this feature is inadequate for a system to be taken into account as a fractal (Warnecke & Hüser) .

Self-Organisation

Self-organisation is an application that fractals are able to apply appropriate methods for controlling the workflow and process, and improve the composition of fractals in the system (Lee, Ryu, & Shin, 2017). Therefore, (Warnecke & Hüser) refers to the freedom of fractals in organisation and implementation functions. Each unit of fractal arranges its internal structure based on previously assigned criteria therefore it does not require external intervention to reorganise itself (Attar[1] & Kulkarni, 2014). A hierarchical structure of control and command does not exist in the fractal system. However, to determine the best fit with the environment, constant reorganisation occurs. The justification of the individual characteristics of units in the fractal system can be obtained using this feature (Sprock, 2018).

Dynamics and Vitality

The dynamics and vitality feature is adapted in order to navigate the system dynamically (Warnecke & Hüser). This feature means adapting with the organisational environment without any changes to the structure of any organisation and cooperation between self-organising fractals (Asnina et al., 2008) & (Tharumarajah et al., 1998). Ryu (2003) points out the vitality is the behaviour of a fractal that can be considered as an essential unit searching for new activities from other units in the system. This feature observes environmental changes and helps the system to adapt quickly with these changes (Tharumarajah et al., 1998). However, this feature concentrated on unit operations among fractals in order to get a dynamic system.

Navigation

Tharumarajah et al. (1998) point out to that navigation feature induces cooperation among fractals. Adding to that, using this feature is to obtain information and to check progress. Ryu (2003) stated that fractals should have the ability to negotiate with other fractals at any time. The properties of navigation are that the fractals constantly reappraise their progress and position, correcting it within a target area if necessary.

Goal-Orientation

Goal-orientation means that each fractal unit has specific individual goals to achieve systems goal. Each fractal units set their goals, which can be different with other fractal units (Lee et al., 2017). This is supported to ensure goal coherence by an inheritance mechanism (Ryu, 2003). Therefore, this feature enables to emerge the goals of the system from the objectives of individual fractals (Warnecke & Hüser)&(Asnina et al., 2008).

Fractal-based System Implementations

The fractal approach has been used by many researchers in different fields in order to solve problems and to provide flexibility and quick adaptability to system changes. In the sector of healthcare management, there is big data (for definition of the big data we refer the reader to the work of (Baro, Degoul, Beuscart, & Chazard, 2015)). Most of the big data is classified as unstructured data. This data is growing faster than the structured and semi-structured data in which the management of them is still a focus for researchers to propose models of information systems that have the capability to handle this unstructured data and for transferring it to useful information for improvement of the healthcare system (Senthilkumar, Rai, Meshram, Gunasekaran, & Chandrakumarmangalam, 2018). A fractal model has been proposed by Ahmed (2013) in which the model seeks to improve the Healthcare Information System (HIS) by serving as a platform for exchanging the healthcare information among physicians within the same hospital and different hospitals. The proposed model provides an effective approach for increasing the cooperation among the physicians in sharing the healthcare information which results in increasing their skills and also patients care is improved due to the reduction in time for accessing patient information. In the manufacturing sector, the fractal approach has been used with the aim of improving the information system most remarkable concepts have been listed in table 2. The fractal model is proposed by Ryu et al.(2003) in which the multi-agent technique is depended where each unit in the manufacturing system is considered as a fractal and consists of five modules (i.e. Analyser, organiser, resolver, reporter and observer), see Figure 4.

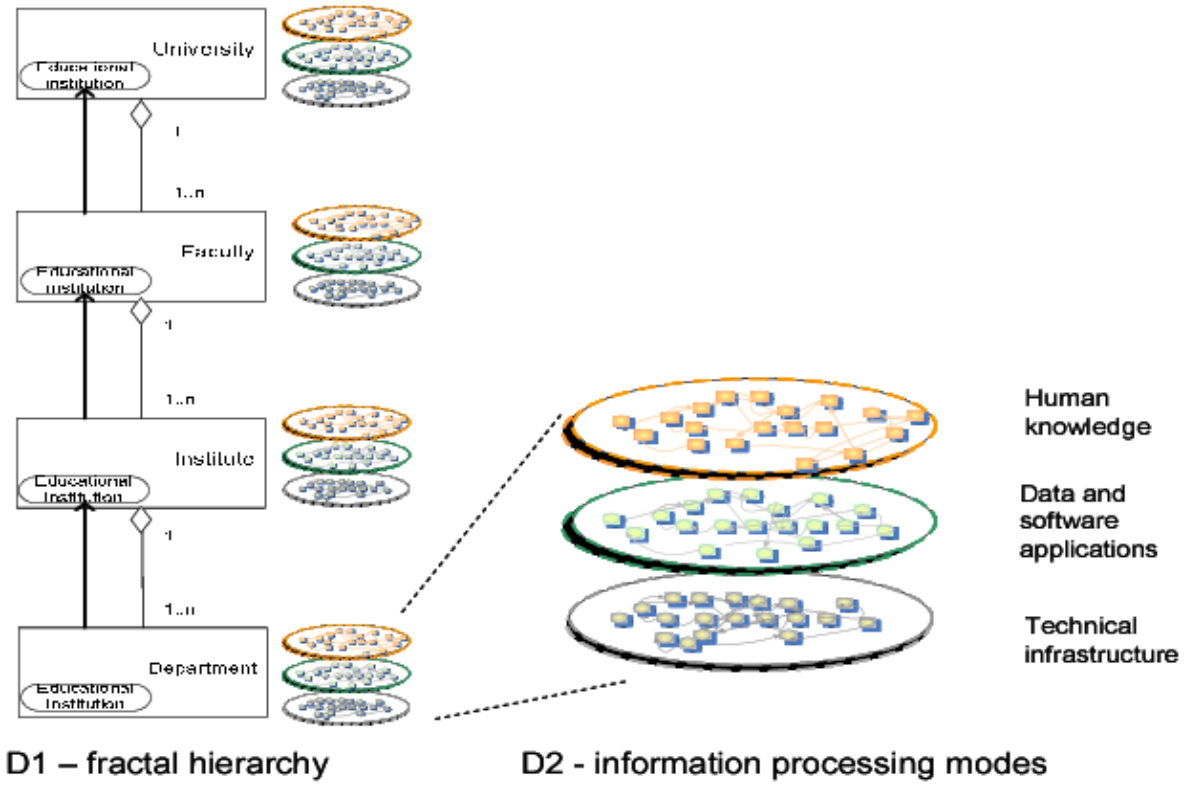
Figure 4. Fractal Architecture, Ryu et al (Ryu, Son, & Jung, 2003)

Table 2: Shows the application of the Fractal philosophy in analysing the issues in different aspect of management

Analysed issue	Remarked Concept	Ref.
Informational Organisational System	Regarding the development of system applications based on the fractal theory, such theory allows application of various methods on different levels of administration in any organisation; Fractal-based applications can lead to informational process development acceleration and a system's management (informational system) change; it provides a dynamic information architecture and a fractal-based informational system;	(Marite Kirikova, 2009b), (Marite Kirikova, 2009a), (Stecjuka, Makna, & Kirikova, 2008)
Organisations Architecture	The organisatiåon's properties can be adapted withfractal architecture; identification of opportunities and limitations of organisations' characteristics can be done with fractal architecture in the companies' models analysis;	(Leitão, 2009), (M Kirikova, Piciocchi, Bassano, Makņa, & Stecjuka, 2011)
Quality Management and Control	Based on the fractal principles, the organisation can evaluate methodology development and analyse its quality; organisational structure based on the sractal can allows continual improvement process regarding the managerial processes;	(Qin, Zhao, Yao, & Xu, 2007), (PRISECARU, NICOLESCU, PERSIDEANU, & MOISE, 2012)
Knowledge Management and Decisional Process	Inspiring a Fractal philosophy on knowledge management of organisation can facilitate the decisional process regarding human resource (investigation methodology, and so on);	(Ionut Viorel Herghiligiu, Lupu, Paius, Robledo, & Kobi, 2013)
Environmental Management System (EMS) Architecture	The integration process of transformation for implementing EMS in any organisation can be done based on Fractal philosophy;	(Ionuţ Viorel Herghiligiu, Mihaela Luminiţa, & Christian, 2012)
Production System Development	Inspiring the Fractal theory in the developing of methods/ models can increase the efficiency and productivity of systems;	(Bin & Gangyan, 2009), (Danli, Leng, & Hongyan, 2011)
Production Systems Organisation According to Fractal Principles	Production systems can be defined based on the fractal architecture and its entities; there is comparison between the hierarchical and fractal architecture; it identifies the description of each agent in the fractal-based system and its associations with other agents; there is also a description of each fractal feature mechanism;	(Ryu et al., 2003),(Ryu & Jung, 2004)

In the sector of education, Kirikova (2009) proposes the flexible information architecture based on the fractal information system in which the integrity of the system should be achieved at different levels of scale in educational institutions starting from the department level (low level) to the University level (high level). The dimension of the information architecture in a fractal system is defined as shown in Figure 5, where the flexibility of the hierarchy can be seen at each level in two dimensional forms. Stecjuka et al., (2008) proposed a fractal enterprise approach to increase the flexibility of a business process in organisational operation and development. The selection of the best practices of a business process among fractals is allowed by this approach, such as an annual report of the scientific activities of institutions. Figure 6 show a hierarchical structure of the organisation of these fractals.

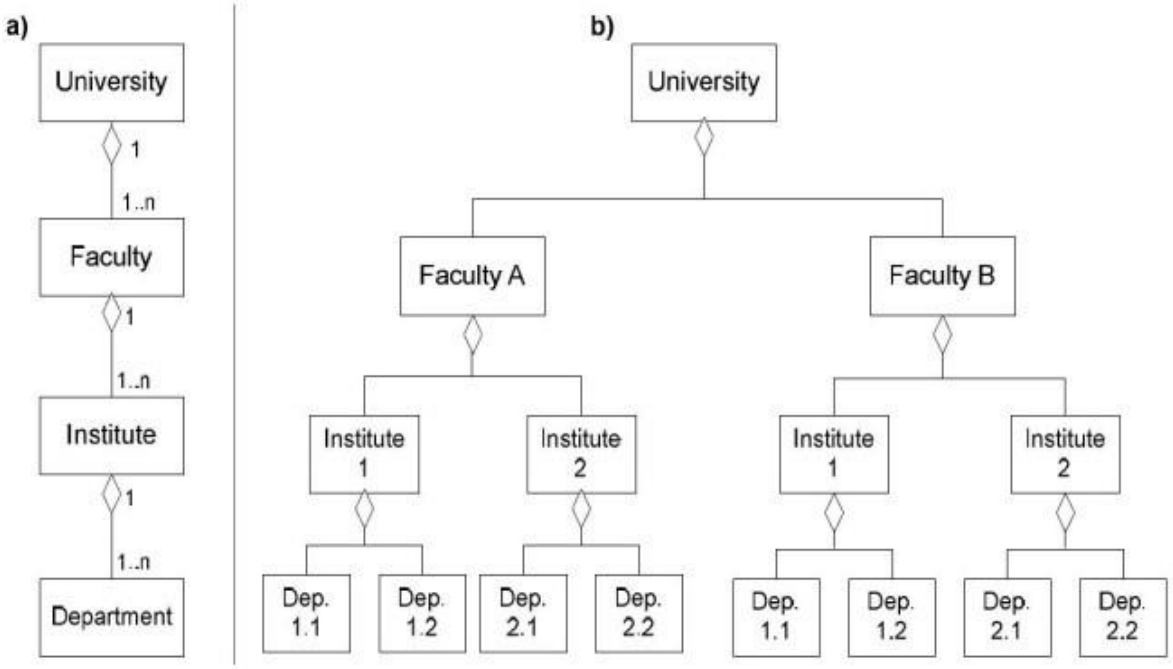
Figure 5. Fractal System Components



By comparison, much less attention has been paid to research concerning the use of fractal theory in the sector of higher education. Therefore, this research seeks to apply the fractal philosophy in designing information systems for higher education institutes in Kurdistan. This will be done to check the suitability of fractal approach application in the student's registration units of each institute.

The Fractal Information Systems

Figure 6. Fractals Hierarchy in a Typical University , Stecjuka, et al (Antonini, Barlaud, Mathieu, & Daubechies)



Any information system developed based on the fractal theory can possess fractal features. In fact, according to (Warnecke & Hüser), information systems need studies to adapt the fractal approach because these systems depend on environment requirements which are constantly needing updates and changes in information and structure (Marite Kirikova, 2009b). ISs consist of autonomous and decentralised process units (Asnina et al., 2008). These units consist of computer software and humans. They can restore and change data to supply information as required (Ahmed, 2013). Thus, (Warnecke & Hüser) thinks that the components of an IS could work as fractal units to create a less complex work system and a flexible vitality system. For this reason, the fractal concept has been utilised in some information systems to achieve a non-complicated sytem structure and to manage and control process activities of the system (Ryu et al., 2003) & (Canavesio & Martinez, 2007). The most important function of the units of an information system is to process data, information and knowledge. In addition, each unit can serve information to other units in order to achieve system goals as well as to provide cohesive cooperation in a fractal approach (Tharumarajah et al., 1998).

Furthermore, an essential advantage of the fractal system is the maximisation of information flow and storage among fractal units (Ryu, 2003). Tharumarajah et al.,(1998) mention that

information flow and storage are achieved in numerous ways, such as information flow inside the fractal itself and among same level fractals, different level fractals, fractal entities and the external environment. The aim of using information flow between the external environment and fractals as well is to increase the cooperation between fractals. The type of this cooperation is utilised relying on the six work environment level: culture, strategic, socio-informal, financial, informational, and technological. The researcher also stated that any systems that have features of self-similarity, self-organisation, goal-orientation and dynamics and vitality are able to adapt into a fractal system.

The use of a fractal approach by researchers in information system domains is not common. The former studies have merely used the fractal approach within manufacturing and healthcare. Adding to that, there are few studies that use the fractal approach in educational institutes. Thus, this work suggests utilising the fractal theory to develop cooperation between the Ministry of Higher Education and Student Registration units of each institute in the Kurdistan Region.

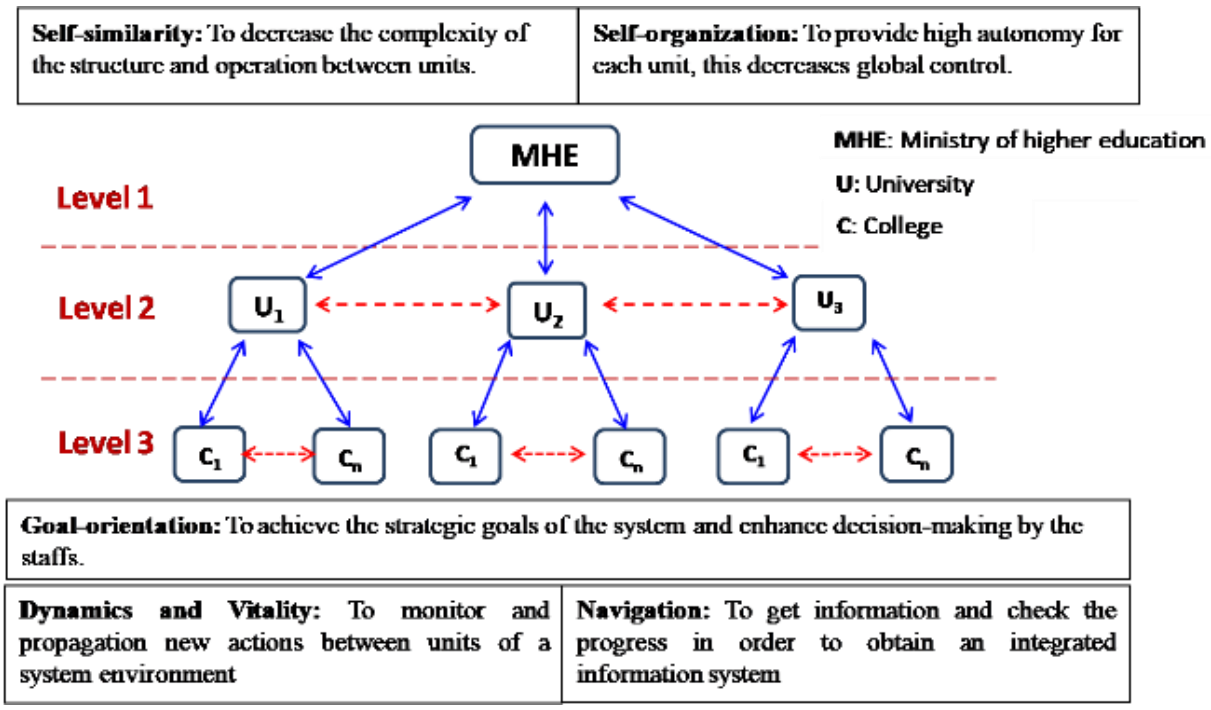
Integrated Educational Institute Information System Based on Fractal Theory

Nowadays, in most Middle Eastern countries the higher educational institutions are suffering from the enormous challenges due to the globalisation and new technology which have influenced many aspects of the business environment, particularly in the higher education sector. Quality of provided services becomes an important aspect that is associated with the reputation of any university for evaluation and assessment system. This task becomes an issue and might be a crucial challenge that cannot be avoided because both teaching and administrative support functions of universities are affected by this quality (Shaban, Salih, & Al-Zaidi, 2015). Moreover, information systems (IS) are considered to be important and substantial resources for organisations to be continuous in today's "technology-focused environment". Organisations have an increased amount of resources for investigation in IS infrastructures to offer better services and products (Sabri, Ahmad, & Abdulrazaq, 2017). The application of computerised student information management systems within the university campus becomes an important keystone to share information among students and staff (Sarhan, Atroshi, & Ahmed, 2016).

There are different systems in the Ministry of Higher Education (MHE) in the Kurdistan Region for students to used when applying for the universities. Student registration units are one of the administrative units in each college or university which provide services to the students. The task and service of this unit is that after declaring a students name in the particular university, based on the student total mark obtained from the high school, the traditional process is to register their name, which in most of the universities in the Kurdistan Region is conducted manually. This system has lots drawbacks such as: first, it is more time-consuming

in managing student data than a computer, especially if they need to scan or fax any documents. Second, from the physical exertion perspective it is difficult to re-file, alter and restore the paper records. Therefore these are non-value added activities (Bharamagoudar, Geeta, & Totad, 2013). Accordingly, we consider that the conventional system is not efficient, and the employee's requirements are not satisfied with the current system. Thus, it cannot provide the optimum information within an efficient time frame. This is due to the lack of the quality of cooperation and integration between the considered bodies (Atrushi & Woodfield, 2018). To over comes these issues, the establishment of online student registration units should be adopted by all universities and the MHE in order to facilitate the work of staff. Collaboration among ministry staff and registration unit employees is a sever issue in sharing information and skills to facilitate student affairs. Both the ministry and the registration unit have the autonomy to process transactions for students, but can also work in either a complementary or cooperative way to exchange student information among them. Based on the fractal concept, the fractal approach has been successfully used for designing integrated cooperative ISs which provide services that are flexible and autonomic with a cooperative method for connecting system units. These system services (i.e. flexibility and complexity) are successfully utilised by the features of the fractal approach in many fields. Therefore, we propose in this work a conceptual framework for integrated cooperative educational institutes' Information systems based on the fractal theory, as shown in Figure 7.

Figure 7. Conceptual framework for integrated cooperative higher education institute's information system based on the fractal theory



In Figure 7, the theory features of fractals are utilised to propose an integrated cooperative higher education institute's information system to overcome all the aforementioned problems. This will be done by connecting all institutes with the MHE, as fractal units, in the Kurdistan Region. These fractal units can work and cooperate together based on the fractal features regarding the registration process of students. The students can register only one time instead of two times as is available in the current traditional system. After the first registration process, the MHE declares the students to admit to the particular department of any institute and send an announcement to that institute. Then, the institute will confirm when students attend the study program. Moreover, the MHE will get this confirmation from the particular institutes. Further, the proposed conceptual framework will have a top-down and bottom-up work flow structure, which is based on the MHE regulations. This means that administrative higher fractals and passive lower fractals as well as coordinative higher fractal and active lower fractals. Such a kind of work can provide more autonomy to each fractal institute in their decision making and planning.

Furthermore, the qualitative research methodology will be used to support the result of this conceptual framework between the MHE and Duhok Polytechnic University (DPU), as a case study. The qualitative research data consists of semi-structured interviews and observations with employees working in the registration units. The aim of this interview is to know the problems faced by employees when registering students and gaps between employees of MHE and DPU regarding the student registration process.

Conclusion

To speedily spread and update essential information in any distributed system, it is important to have communication and coordination between units. In most distributed systems, the cooperation and flexibility among different units of the system can be obtained via availing from the feature of the fractal approach. Fractal theory has been utilised in most studies to inspire a concrete cooperation among an organisation's units and provide a flexible structure of any organisational environment. This means inspiring the fractal features in any system, can provide a flexible and adaptable to environment changes. Distributed educational information systems would be more flexible if they are inspired by the features of the fractal method. A student registration unit can be considered a fractal system if it has independent units connected by the fractal features (self-similarity, self-organisation, dynamics and vitality, navigation and goal-orientation). The proposed conceptual framework of integrated cooperation among educational institutes based on the fractal concept can provide a good solution for facilitating the registration process of newly admitted students. Also, other benefits can be reached such as easy management and control of the complexity of a registration system by breaking the system into small similar units, as fractals, highly autonomous system units, which means each

unit can choose its own plans, have increased flexibility of the system structure and can easily transfer productive information among system units. Indeed, this work will be the bedrock of developing a fractal-base system in higher education institutes in the Kurdistan Region.

REFERENCES

Abdulazeez, A. M., Zeebaree, S. R., & Sadeeq, M. A. (2018). Design and Implementation of Electronic Student Affairs System. *Academic Journal of Nawroz University*, *7*(3), 66-73.

Ahmed, N. S. (2013). *A fractal-based model to improve cooperation among physicians in distributed healthcare information systems.* University of Malaya.

Ahmed, N. S., & Yasin, N. M. (2012). *Improvement the cooperation feature in distributed healthcare information systems based on the fractal approach: An empirical study*. Paper presented at the Advanced Materials Research.

Amini, M., Ahmad, M. O., & Swamy, M. (2014). *Image denoising in wavelet domain using the vector-based hidden Markov model.* Paper presented at the New Circuits and Systems Conference (NEWCAS), 2014 IEEE 12th International.

Antonini, M., Barlaud, M., Mathieu, P., & Daubechies, I. (1992). Image coding using wavelet transform. *IEEE transactions on Image Processing*, *1*(2), 205-220.

Asnina, E., Osis, J., & Kirikova, M. (2008). *Design of Fractal-Based Systems Within MDA: Platform Independent Modelling.* Paper presented at the SIGSAND-EUROPE.

Atrushi, D. S., & Woodfield, S. (2018). The quality of higher education in the Kurdistan Region of Iraq. *British Journal of Middle Eastern Studies*, 1-16.

Attar[1], M. A., & Kulkarni, M. L. (2014). Fractal manufacturing System–Intelligent control of manufacturing industry.

Baro, E., Degoul, S., Beuscart, R., & Chazard, E. (2015). Toward a literature-driven definition of big data in healthcare. *BioMed research international*, *2015*.

Bharamagoudar, S., Geeta, R., & Totad, S. (2013). Web based student information management system. *International Journal of Advanced Research in Computer and Communication Engineering*, *2*(6), 2342-2348.

Bin, H., & Gangyan, L. (2009). *Configuration unit for product self-organising configuration design and its application.* Paper presented at the Natural Computation, 2009. ICNC'09. Fifth International Conference on.

Bodunkova, A. G., & Chernaya, I. P. (2012). Fractal organisation as innovative model for entrepreneurial university development. *World Applied Sciences Journal*, *18*, 74-82.

Canavesio, M. M., & Martinez, E. (2007). Enterprise modeling of a project-oriented fractal company for SMEs networking. *Computers in Industry*, *58*(8-9), 794-813.

Danli, D., Leng, J., & Hongyan, Z. (2011). *A ship manufacturing model for fractal-based green supply chain.* Paper presented at the Management Science and Industrial Engineering (MSIE), 2011 International Conference on.

Herghiligiu, I. V., Lupu, L. M., Paius, C. M., Robledo, C., & Kobi, A. (2013). *Organisational employee seen as environmental knowledge fractal agents as a consequence of the certification with ISO 14001.* Paper presented at the International Conference on Intellectual Capital and Knowledge Management and Organisational Learning.

Herghiligiu, I. V., Mihaela Luminiţa, L., & Christian, R. (2012). Necessity of Change Environmental Management System Architecture-Introduction. *Quality-Access to Success*.

Hongzhao, D., Dongxu, L., Yanwei, Z., & Ying, C. (2005). A novel approach of networked manufacturing collaboration: fractal web-based extended enterprise. *The International Journal of Advanced Manufacturing Technology, 26*(11-12), 1436-1442.

Kirikova, M. (2009a). *Towards flexible information architecture for fractal information systems.* Paper presented at the Information, Process, and Knowledge Management, 2009. eKNOW'09. International Conference on.

Kirikova, M. (2009b). Towards multifractal approach in IS development *Information Systems Development* (pp. 295-306): Springer.

Kirikova, M., Piciocchi, P., Bassano, C., Makņa, J., & Stecjuka, J. (2011). *IS Based Best Process Practices Propagation in Fractal Enterprises: a Viable Systems Perspective.* Paper presented at the Proceedings of the 10th International Conference on Business Informatics Research (BIR 2011), Niedrite L., Strazdina R., Wangler B.(Eds.), Latvia, Riga.

Lee, S., Ryu, K., & Shin, M. (2017). The development of simulation model for self-reconfigurable manufacturing system considering sustainability factors. *Procedia Manufacturing, 11*, 1085-1092.

Leitão, P. (2009). Agent-based distributed manufacturing control: A state-of-the-art survey. *Engineering Applications of Artificial Intelligence, 22*(7), 979-991.

Monostori, L., Váncza, J., & Kumara, S. R. (2006). Agent-based systems for manufacturing. *CIRP Annals-Manufacturing Technology, 55*(2), 697-720.

Poenaru, C. E., Dobrescu, R., & Merezeanu, D. (2017). *Fractal Organisation in Healthcare Information Systems.* Paper presented at the Control Systems and Computer Science (CSCS), 2017 21st International Conference on.

Prisecaru, B., Nicolescu, D. V., Persideanu, V., & Moise, A. V. (2012). The Process Approach As A Fractal Structure For Continuous Improvement Of The Organisations. *Scientific Bulletin journal, Series D, ISSN*, 1454-2358.

Qin, Y., Zhao, L., Yao, Y., & Xu, D. (2007). *A study on inter-enterprise quality control function self-organisation reconfiguration based fractal networks.* Paper presented at the Robotics and Biomimetics, 2007. ROBIO 2007. IEEE International Conference on.

Ryu, K. (2003). Fractal-based reference model for self-reconfigurable manufacturing systems. *Doctor of Philosophy PhD, Department of Industrial Engineering, Pohang University of Science & Technology*.

Ryu, K., & Jung, M. (2004). Goal-orientation mechanism in a fractal manufacturing system. *International Journal of Production Research*, *42*(11), 2207-2225.

Ryu, K., Son, Y., & Jung, M. (2003). Modeling and specifications of dynamic agents in fractal manufacturing systems. *Computers in Industry*, *52*(2), 161-182.

Sabri, S. Q., Ahmad, A. M., & Abdulrazaq, M. B. (2017). Design and Implementation of Student and Alumni Web Portal. *Science Journal of University of Zakho*, *5*(3), 272-277.

Sarhan, L. I., Atroshi, A. M., & Ahmed, N. S. (2016). A Strategic Planning of Developing Student Information Management System Using SWOT. *Journal of University of Human Development/Vol*, *2*(3).

Senthilkumar, S., Rai, B. K., Meshram, A. A., Gunasekaran, A., & Chandrakumarmangalam, S. (2018). Big Data in Healthcare Management: A Review of Literature. *American Journal of Theoretical and Applied Business*, *4*(2), 57-69.

Shaban, A., Salih, M. Q. D., & Al-Zaidi, H. A. W. (2015). The impact of creativity elements on educational service quality dimensions–an exploratory study of academic staff perceptions in Duhok Polytechnic University.

Sprock, T. (2018). Self-similar architectures for smart manufacturing and logistics systems. *Manufacturing Letters*, *15*, 101-103.

Stecjuka, J., Makna, J., & Kirikova, M. (2008). *Best practices oriented business process operation and design.* Paper presented at the Proceedings of the 9th Workshop on Business Process Modeling, Development and Support Business Process Life-Cycle: Design, Deployment, Operation & Evaluation Proceedings of the BPMDS 2008 Workshop held in Conjunction with the CAiSE 2008 Conference Montpellier, France, June.

Tharumarajah, A., Wells, A., & Nemes, L. (1998). *Comparison of emerging manufacturing concepts.* Paper presented at the Systems, Man, and Cybernetics, 1998. 1998 IEEE International Conference on.

Warnecke, H., & Hüser, M. The Fractal Company: A Revolution in Corporate Culture, 1993. *Springer-Verlag, UK)*, *4*, 217-226.

Xiaohua, Z., Wei, C., Yanming, S., & Shixiong, Z. (2006). The modeling of complex system based on dynamic control cell structure.

Zhao, L., Qin, Y., Yao, Y., & Yan, P. (2014). A system framework of inter-enterprise machining quality control based on fractal theory. *Enterprise Information Systems*, *8*(2), 336-353.

Zeebaree, D. Q., Haron, H., Abdulazeez, A. M., & Zebari, D. A. (2019). *Machine learning and Region Growing for Breast Cancer Segmentation.* Paper presented at the 2019 International Conference on Advanced Science and Engineering (ICOASE).