A Model Study on Hierarchical Assisted Exploration of RBAC

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ABSTRACT

The role-based access control (RBAC) system has been widely used in data security because of its good flexibility and security, wherein RBAC dominates the field of access control. However, the process of establishing RBAC roles is complex and time-consuming, which hinders the development and application of this field. Recently, the introduction of expert interactive Q&A algorithm based on attribute exploration has greatly reduced the complexity and time consumption of the RBAC role building process. However, when attributes increase, algorithms will face challenges that the time complexity will explode exponentially with the increase of attributes. To cope with the above problems, this paper proposes a hierarchical assisted exploration model of RBAC under attribute-based exploration expert interactive Q&A algorithm framework from the view of reducing the time consumption of overall and single role engineering. This model not only avoids the time-consuming process of single role requirements, but also reduces the time-consuming process of whole role establishment from the overall architecture perspective.

KEYWORDS

Access Control, Concept Lattice, Expert Interactive Q&A System, Formal Concept Analysis, Hierarchical Exploration, Information Security, Machine Learning, Role Engineering, System Security

INTRODUCTION

With the explosive rate of global information system, an increasing portion of information sharing is becoming an information security catastrophe. (Qiu et al., 2020) summarizes the documents in the field of information security in recent years, which indicates that information security is an urgent problem to be solved in the field of the Internet of things. The increasingly serious problem of information disclosure and security attacks has a dramatic impact on personal and national security (Michel & King, 2019).

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In order to prevent the destruction or disclosure of information caused by the intrusion of illegal users or the careless operation of legal users, many scholars have proposed a variety of solutions to insure the security of the information system. Access control (Sandhu & Samarati, 1994) has gradually become a fundamental tenets of information system. Access control restricts the permissions of users to access system resources, and resources that exceed user permissions are not allowed to be accessed. The existing access control methods form two main group: autonomous control (Downs et al., 1985) and mandated access control (Jiang et al., 2004). In automatic access control, users can divert permissions directly or indirectly to other users. In spite of its great versatility and unlimited redirect ability, it makes information disclosure possible. On the other hand, the mandatory access control strictly limits the user permissions in the system, but lacks flexibility. In order to ensure the flexibility under the premise of system security, role-based access control (Samarati & Vimercati, 2011; Sandhu et al., 1996) arises at the historic moment, and dominates a mainstream position in the field of access control. The RBAC model introduces the role between users and permissions and regards roles as a bridge between users and permissions, and grants and revokes user access permissions by distributing and canceling roles to users, thus bringing about the logical separation (HC, 2019) between users and access permissions.

However, the complexity of RBAC model is getting higher and higher (Bertino, 2003) with the increasing complexity of information systems. In the design and application of traditional RBAC, system analysts and administrators restrict the relationship between "users and roles" and "roles and permissions" according to their intuitive experience and system requirements. With the research of the information system, the information system is becoming more and more complex and multifarious. In the meantime, the number of access control users and permission resources is also increasing in the system, which makes the information system face some drawbacks (Alessandro & Alberto, 2012). It is often difficult to meet the functional and security needs of users only relying on manpower to design and manage a RBAC system. On the other hand, the high time complexity about conventional RBAC systems and the unavailability to obtain the hierarchical relationship (Vaidya et al., 2007) between roles have turned out to be the fatal flaws of the conventional RBAC.

As modern machine learning advances and flourishes, it provides us with new inspirations and approaches to settle the problem. Machine learning has been widely used in a variety of areas (Zhang et al., 2014; Yin et al., 2017). An approach to mathematics (Concept lattice) (Zhang et al., 2014, Yang et al., 2021) is capable of resolving issues of the role generation. An assisted interactive quizzing algorithm based on attribute exploration is put forward, and obtained the hierarchical relationship between roles in RBAC system by using the expert interactive question and answer under attribute exploration. The partial order relation of system roles can be obtained because of the attribute exploration algorithm is a vital recipe for concept lattice (Ganter & Wille, 2012). In addition, concept lattice has recently been extensively applied in statistical analytics (Jabbari & Stoffel, 2018), knowledge discovery (Shen et al., 2020, Mahani & Baba-Ali, 2019), rule extraction (Ling et al., 2020) and access control (Chandra et al., 2018; Yang et al., 2021; Obiedkov et al., 2009).

Although the expert interactive question and answer algorithm based on attribute exploration can heuristicsly complete the establishment process of RBAC with the increase of user and permission resources, the complexity of construction process of RBAC roles will explode exponentially. Therefore, a novel hierarchical assisted exploration model based on RBAC (RHAE) is proposed from the point of view of reducing the time-consuming of the whole system and local subsystems in this paper. Under the framework of expert interactive question and answer based on attribute exploration, a method is designed to reduce the time-consuming construction of a single role while the hierarchical architecture reduces the time-consuming of the whole RBAC modeling, and also obtains the partial order relationship between roles, which greatly improves the efficiency of the construction of the whole RBAC system and greatly reduces the complexity of RBAC system management.

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