"And the Lord said, 'Behold, they are one people and they have all one language; and this is only the beginning of what they will do.'"

Genesis 11:6

"Data Security is a crucial issue in the database management systems, more important than in any other type of software. As a matter of fact, data are the most sensitive part of any system and its loss or compromise can have disastrous consequences."

S.M. Miranda

Data Security in Centralized and Distributed Data Base Management System [MIR77].
7.1 Introduction

Our major goal in this research has been to design access control mechanism in DHDBMSs which are built by combining existing DBMSs. Site autonomy must be retained for each DBMS. A general architectural model for DHDBMS has been presented. An access control model for a centralized DBMS has been extended for a DHDBMS.

We have identified problems which arise when Content-dependent and Functional access control is enforced in a DHDBMS. Because of the incompatible access control mechanisms in the DBMSs at the local sites, a uniform access control mechanism for enforcing Content-dependent and Functional access control policies is needed at the global level. Furthermore, site autonomy of the local systems requires that each local system controls its own data, and this adds an inconsistency problem in the access control policy.

We have proposed a solution which allows Content-dependent and Functional access control policies to be enforced in a DHDBMS. Moreover, uniform global access control policies can be enforced while retaining site autonomy for the local systems.

7.2 Observation

The proposed access control mechanism has some
important implications. First, Content-dependent and Functional access control policies can be achieved for component DBMSs which are not capable of implementing these access control policies themselves. Second, site autonomy at each site has been retained.

Our proposed access control mechanism does not affect much the functionality of the components in our model. For example, query processing is not changed when access control mechanism is added to the model. However, a minor modification is needed during query translation and distribution of subqueries to different sites. Also, the access control components must be invoked and cooperate with the other components of the system (i.e. query processing). Some changes may have to be incorporated in accounting module also. Since we use view mechanism for the Content-dependent access control, therefore we need to have a command to define a view. For the flexibility and dynamic change for the access rule, access rights to the protected database object can be granted and revoked. A facility will have to be added to accomplish these tasks.

The Content-dependent and Functional access control mechanism requires careful synchronization of the processing of subqueries generated during execution plan of the query or a program. The concurrency control mechanism must be enhanced to handle this. Since the Content-dependent and Functional Access Control mechanism depends on
the capability of the concurrency control mechanism, the importance of the concurrency control to the security enforcement is evident here.

7.3 Future Work

Future work can proceed in several directions. An area that can be explored is the implementation and testing of access control mechanism in DHDBMS. The conceptual DHDBMS model for integrating existing DBMSs provides the necessary framework to implement such a heterogeneous DHDBMS with access control mechanism.

We have focussed this study on Content-dependent and Functional access control policies. There are other security policies such as Context-dependent and History dependent [FER80] which need investigation. By using suitable predicates, certain type of Context-dependent access control can also be specified. For example, a predicate could enumerate fields that should appear together in a query. Such cases can be handled through view mechanism, but a generalized solution is needed. Application program authorization technique may prove to be very useful in providing Context-dependent and History-dependent access control. In addition to application program authorization technique, some sort of inferencing capability will also be needed in the system to provide History-dependent access control. [THU87] discusses
security checking in relational DBMS augmented with inference engines. Possibility should be explored to apply such type of techniques for DHDBMSs.

We have implicitly assumed that some authorizer can give access rights to other users. This is known as discretionary access control [FER80]. We have discussed such type of access control till now. A simpler but less flexible approach is to compartmentalize the use of the system and follow the fixed policy that data belonging to one compartment or category cannot be accessed by users assigned to another category. This is an example of nondiscretionary access control [FER80]. An extension to the compartmentalization policy is the multilevel control policy, which is often used in military installations. [DWY87] discusses multi-level security in relational database management systems. Possibility should be explored for the use of such an access control mechanism for DHDBMSs.

7.4 Summary

It is expected that in the coming years, the DHDBMS technology is going to play an important role in Information Technology. It is clear from the earlier discussions, that data security aspect will have to be foolproof in the DHDBMSs. If this aspect is lacking in a DHDBMS environment, then no organization would come forward to integrate its own DBMSs to such environment. We have
also discussed that access control is an important factor in data security. We have proposed access control mechanism for DHDBMSs.

It is felt that the DHDBMS technology will enable a user to cross many barriers (like heterogeneity and distribution of databases) in securing information. I dream of a day when a little literate Indian farmer using a remote terminal in the village to communicate with the world outside, will be able to access vital information on agriculture, cattle and poultry raising, on his public health requirements, and on a hundred other subjects of importance to him. I hope, the DHDBMS technology will help a lot in making this dream a reality.