The conventional Internet architecture was designed in a static environment: wired-line with stable electronic signals and low-speed stationary desktops not suitable for complex networking processing. However, as the Internet evolves in both technologies and contents, there are new requirements for more flexible or reliable services such as fault-intolerant session-based application, especially when less reliable wireless access technologies, together with them are nomadic-related issues, become widely available.

These new requirements can be addressed more easily if the applications can manipulate information across layer of the TCP/IP protocol stack. And there are two objectives of a cross-layer system. (Objective-a) is to allow exchange of information and possibly commands among layers so that a protocol instance of a layer can harmonize its activities with the condition of other layers. And (objective-b) is to allow for the safe update (or modification) of a protocol’s parameter so that the internal state of a protocol can be altered and adapted to the changes of external environment.

However, because (objective-b) requires the cross-layer system to be able to identify and access an individual instance of a protocol, no existing works support it.

The purpose of this research is to propose a new TCP/IP networking architecture called the InterLay model that can facilitate the sharing and manipulation of information across layers’ borders in a general, comprehensive and secure manner to support both objective-a & b discussed above.

In chapter 1 of the dissertation we introduce the history of the development of the conventional TCP/IP architecture, and how the principle of layering has facilitated the development of the Internet. This chapter also explores the recent changes to the Internet world, making the requirements of the layering principle too stringent. Finally, the objectives of the research are specified, which focuses on addressing the above mentioned problems.

Chapter 2 first explores the limitations of the layering principle in today communication environment, which prevent high layers from synchronizing their operations with the condition of lower ones. Because of the development of new services and hardware, there are cases where these limitations are not preferable. The chapter then explores results and also limitations the existing works that try to overcome the inadequacy of the TCP/IP layering principle. Some of these works focus on making changes to the architecture to adapt to a new feature on a case-by-case basis. Others, although of general purpose cross-layer information exchange approach, only support (objective-a) because they are not designed to identify an individual protocol instance or to support a secure way to access and alter the value of a parameter.

In chapter 3, the detailed design of the new InterLay model for TCP/IP architecture is provided. The InterLay model will have to support both objectives explained above.

The InterLay entity is consisted of three distinct functional groups, namely the Policy Element (PE), the Enforcer and the Informer, is explained. The PE is the checkpoint to authorize requests that can potentially affect the TCP/IP protocol stack (namely the update of parameter’s value, executing a networking protocol procedures and registering for an event), as well as to authenticate requests from external entity. The Informer is in charge of returning the current value of a networking parameter, as well as informing the requester of the occurrence of a registered event. The Enforcer carries out the actual update or alternation of parameter value, as well as executes networking procedures. The InterLay model uses the Enforcer to support (objective-b) described above. The Enforcer also contains security measures to safeguard its actions.

This chapter also provides the specifications of new system calls that allow the user application to control the underlying NS. Finally, the interaction scenarios between InterLay and various entities are provided.

In chapter 4, we explain the need to find all the right parameters which will assist the developers in the service and protocol development process which can save development time for cross-layer services. Test questions are defined and used as a method to find those parameters. The test questions are then applied to various protocols in each layers of the TCP/IP protocol family. The parameters that are found are summarized for each layer.

One important aspect of the test question approach is that its methodology and results can be applied not only the InterLay but to any other systems that provide cross-layer control.

Chapter 5 first discusses the coverage of the InterLay model over the existing and potential future requirements toward the conventional TCP/IP architecture. It explores
how InterLay supports mobility (including maintaining TCP sessions across IP subnet handover and route optimization), fault-tolerance and insertion of SHIM Layer header. Advantages and benefits of the Interlay model are analyzed in comparison with related systems. The deployment strategies for the new architecture are also provided in two modes, namely disruptive and non-disruptive deployment. Some related issues on overhead in OO programming, performance and security are also discussed.

The major contributions of the research are summarized in chapter 6. The InterLay model is the only solution for cross-layer manipulation that supports the "write" operation of protocols' parameters. The InterLay can be used to implement and monitor various aspect of a new feature, and the information obtained from this process can serve to speed up the development of the correspondent protocol. So the InterLay model can be used as a testbed to develop protocols for the TCP/IP architecture!

Future works to fulfill the potential of the proposed architecture are also suggested in chapter 6.