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Router Plugins
A Software Architecture for Next Generation Routers

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1. ABSTRACT

Present day routers typically employ monolithic operating systems which are not easily upgradable and extensible. With the rapid rate of protocol development it is becoming increasingly important to dynamically upgrade router software in an incremental fashion. We have designed and implemented a high performance, modular, extended integrated services router software architecture in the NetBSD operating system kernel. This architecture allows code modules, called *plugins*, to be dynamically added and configured at run time. One of the novel features of our design is the ability to bind different plugins to individual flows; this allows for distinct plugin implementations to seamlessly coexist in the same runtime environment. High performance is achieved through a carefully designed modular architecture; an innovative packet classification algorithm that is both powerful and highly efficient; and by caching that exploits the flow-like characteristics of Internet traffic. Compared to a monolithic best-effort kernel, our implementation requires an average increase in packet processing overhead of only 8%, or 500 cycles/2.1ms per packet when running on a P6/233.

1.1 Keywords

High performance integrated services routing, modular router architecture, router plugins

2. INTRODUCTION

New network protocols and extensions to existing protocols are being deployed on the Internet. New functionality is being added to modern IP routers at an increasingly rapid pace. In the past, the main task of a router was to simply forward packets based on a destination address lookup. Modern routers, however, incorporate several new services:

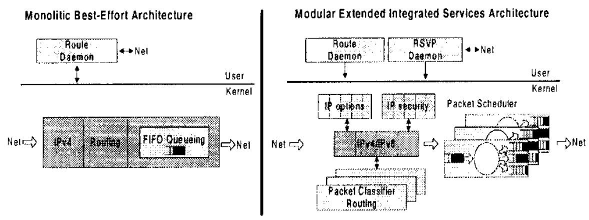

Figure 1. : Best Effort vs Extended Integrated Services Router (EISR)

- Integrated/differentiated Services
- Enhanced routing functionality (level 3 and level 4 routing and switching, QoS routing, multicast)
- Security algorithms (e.g. to implement virtual private networks (VPN))
- Enhancements to existing protocols (e.g. Random Early Detection (RED))
- New core protocols (e.g. IPv6 [8])

Figure 1 contrasts the software architecture of our proposed Extended Integrated Services Router (EISR) with that of a conventional best-effort router. A typical EISR kernel features the following important additional components: a packet scheduler, a packet classifier, security mechanisms, and QoS-based routing/Level 4 switching. Various algorithms and implementations of each component offer specific advantages in terms of performance, feature sets, and cost. Most of these algorithms undergo a constant evolution and are replaced and upgraded frequently. Such networking subsystem components are characterized by a relatively "fluid" implementation, and should be distinguished from the small part of the network subsystem code that remains relatively stable. The stable part (called the core) is mainly responsible for interacting with the network hardware and for demultiplexing packets to specific modules. Different implementations of the EISR components outside of the core often need to coexist. For example, we might want to use one kind of packet scheduling on one interface, and a different kind on another.

In this paper, we propose a software architecture and present an implementation which addresses these requirements. The specific goals of our framework are:

- **Modularity**: Implementation of specific algorithms come in the form of modules called *plugins*[1].

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