Radio+Tuner: A Tunable Distributed Object Store
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1 Problem Statement
The primary reason for diversity of distributed storage systems is that no single design for a distributed storage system is cost-optimal for meeting the latency and throughput SLOs in all possible workloads. In other words, a distributed object store that satisfies the SLOs for a particular workload at minimum cost (in comparison to other object stores) will incur higher costs than alternate storage systems on other workloads.

Therefore, an application administrator today is faced with the onerous task of choosing from the large variety of available object stores; an incorrect choice may significantly inflate costs necessary to meet performance SLOs. Furthermore, as new workloads emerge, none of the existing systems may be a good match, thus necessitating the development of new object stores. This is because existing systems are inflexible, having assumptions of their target workload are baked into their implementation, and making it unclear how any particular system should be modified in order for it to be well-suited for a workload other than that for which it was designed. While any existing system can likely meet an application’s performance goals with infinite resources, we believe this is the wrong approach.

2 Motivation
Our work is motivated by the inter-dependence between the configuration in which data is stored and the hardware necessary to meet performance SLOs. We demonstrate this using three object stores—HDFS, Voldemort, and Haystack—that have been designed for disparate workloads. HDFS, which mimics the design of GFS, is well-suited for storing and processing large objects at high throughput. Voldemort mimics the design of Dynamo, which was designed to store shopping carts on Amazon and to serve GETs/PUTs on these small objects with low latencies. Finally, Haystack is designed to store photos uploaded to Facebook, and is optimized to enable low-latency reads on write-once read-many objects. Since Haystack is not available for public use, we use Bitcask to build Haystack*, an imitation of Haystack’s design.

We test the performance offered by these three object stores on the three workloads that are the target workloads for these systems. Though these workloads are relatively simplistic (e.g., we consider no skew across objects either in terms of size or read/write rates), these suf-fice for our purpose of demonstrating the variance in a particular system’s performance across workloads. For each (object store, workload) pair, we plot the ratio of the GET latency SLO for that workload to the corresponding percentile of GET latencies measured when using that object store to serve the workload (Figure 1). For example, the bar for Voldemort on Workload2 is the ratio of 100 ms (the SLO in Workload2) to the 99th percentile GET latency when using Voldemort for Workload2.

Overall, though the cost of hardware was the same in the deployments of all three object stores, the ability to meet the performance SLOs associated with a particular workload varies significantly across the object stores. In all cases where the SLOs were not met, a larger storage cluster would be necessary, thus showing that the wrong choice of storage configuration can inflate the cost necessary to meet performance SLOs.

We observe that existing object stores are inflexible because they choose to implement each of their components in one particular manner—that which is best suited for the system’s target workload. As a result, though these systems expose several configuration parameters and tweaking these parameters can significantly vary performance, the range of parameters is limited.

3 Overview
Motivated by the inflexibility of existing object stores, we design a tunable object store, Radio, and its associated configuration engine, Tuner. At this time, Radio offers a simple PUT/GET interface (Figure 2), but is extensible to other types of transactions.

3.1 Radio object store
In contrast to existing object stores, Radio makes no a priori assumptions of its input workload. Radio can be deployed in a range of configurations, and in any particular deployment scenario, one can tune it to that configuration which is well-suited for the target workload.

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Radio’s design is based on the principle of separating mechanism from policy. We partition Radio into the logical components that any object store must implement—storing metadata on how objects are split into chunks, storing metadata of where chunks are stored on disk, and storing the chunks themselves on disk. We permit several implementations of each component, with all implementations of a component exporting the same interface. Each of the implementations for any component presents a different trade-off between performance and cost. Thus, in any particular deployment scenario, we can select a specific implementation for each of Radio’s components, such that the chosen combination of implementations is well-suited for the target workload. Moreover, as new workloads emerge, we need only add new implementations for specific components rather than develop a new object store. Since new implementations of a component export the same interface, they can be paired with any one of the implementations of the other two components.

### 3.2 Configuring Radio with Tuner

Though the Radio object store is tunable, choosing the right configuration for it manually will be onerous. For every deployment, it is impractical for one to choose the right configuration of Radio by testing each empirically.

Therefore, we develop Tuner—a configuration engine associated with the Radio object store. To select the appropriate configuration of Radio for any given deployment, Tuner takes as input characterizations of the 1) cluster hardware, 2) application’s workload, 3) performance SLOs, and 4) available implementations of Radio’s components. Given these inputs, Tuner abstractly navigates the search space of all possible configurations of Radio. For each configuration, Tuner estimates the cost of hardware that will be necessary to meet the performance SLOs if Radio were deployed in that particular configuration. Tuner then picks that configuration with the lowest cost estimate.

### 4 Initial Results

Our initial results demonstrate that our implementation of Radio can adapt well to different workloads.

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**Figure 2:** Interaction between Radio’s components to serve GETs

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