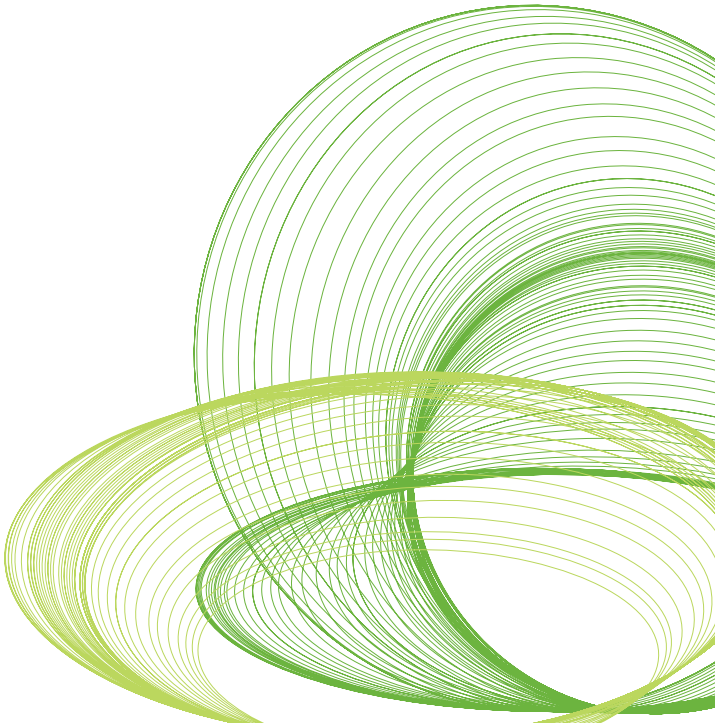
QlikView

QLIKVIEW SCALABILITY OVERVIEW

QlikView Technology White Paper Series



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Introduction

As the needs increase to deploy a system to larger numbers of users, containing larger volumes of data and larger numbers of applications, often in different geographies, scalability becomes increasingly important.

When planning a QlikView deployment for either the first time or an expansion to an existing deployment, a key question always arises: what machines do I buy and when? The answer to this question can be very simple or quite complex depending on a range of considerations, chief among them are:

- The size and nature of source data.
- The number of concurrent users.
- The way that data and applications are organized in a QlikView deployment.
- GUI design and overall application design.

QlikView's performance scales uniformly with data and users.
QlikView scales uniformly as more data is added to the application and more users access the application. Terabytes of data have been addressed in QlikView and many thousands of concurrent users have been shown to repeatedly access deployments without interruption of service.

These 4 general areas –

- Size of Data
- Number of Users
- Number of Applications
- Application Design

are the driving dimensions through which we will discuss QlikView's ability to scale.

We will discuss the challenges associated with each dimension, the approach QlikView recommends and some real-life examples from our customer community.

This paper outlines the technical capabilities, real-world examples and the trade-offs associated with understanding the predictable and proportional response of a QlikView deployment to the challenges associated with scalability.

We will define scalability as "the ability to retain performance levels when adding additional data, users, and applications and when changing the applications' designs."

This paper will examine scalability from an end-user's perspective (i.e. end-user performance) rather than a server-side data reload perspective.

We will also take a look at Scalability Center results that examine whether QlikView scales predictably under typical usage scenarios and will examine QlikView's response to common deployment scalability factors.

It is recommended to review the QlikView Architecture and System Resource Usage Technical Brief in order to get a fundamental understanding of the various QlikView components and how they utilize various hardware resources such as RAM and CPU.

The Four Dimensions of QlikView Scalability

SIZE OF DATA:

It's a well known fact that the data volumes organizations are generating are increasing at a rapid pace. This is no different in Business Intelligence (BI). Even as volumes increase, there is an increased demand on BI systems to continue to provide end users with a high performing and predictable experience. For traditional query-based solutions, this has resulted in a push for faster and more expensive database query acceleration technology, with mixed results. For new technology solutions that use an in-memory solution like QlikView, it's particularly important to understand the system's reliance on Random Access Memory (RAM) resources.

THE QLIKVIEW APPROACH:

Fundamentally, it's important to note that QlikView's performance scales uniformly with data loads. As more data is added to a QlikView application, then a corresponding addition of a combination of RAM and CPU capacity allows end-user performance to be maintained in a predictable fashion.

QlikView relies heavily on RAM due to its in-memory architecture. Please refer to the QlikView Architecture and System Resource Usage Tech Brief which takes a close look at the role that RAM plays in a QlikView deployment.

Let's take a look at the importance of considering adding both RAM and CPU capacity in order to maintain end-user performance when data sizes increase.

As an in-memory based technology, as more data is added to an application it's pretty obvious why more RAM capacity will be needed in order to maintain performance levels. Even though QlikView will utilize the operating system's virtual memory capability (i.e. using the hard drive to 'act' as RAM), the performance degradation associated with this option may result in an unacceptable user experience. QlikView takes advantage of the fact that RAM costs are continuously being driven lower, so adding more RAM capacity owing to an increase in data volumes requires a relatively small capital outlay. QlikView also employs a sophisticated data compression algorithm (as outlined in the QlikView Architecture and System Resource Usage Tech Brief) to allow for an extremely efficient usage of available RAM resources for data analysis. Compression ratios can range from 20% to 90%, depending on the nature of the data being compressed.

It may be less obvious why CPU capacity must be considered when scaling up data. As stated in the QlikView Architecture and System Resource Usage Tech Brief, CPU cycles are used whenever a user interacts with a QlikView application. For example, whenever a chart is recalculated or whenever a new aggregation is requested, CPU cycles are consumed. For any given application, the amount of time needed to respond to an end-user request is a function of the CPU's ability to process the request, perform a recalculation on the data and redraw the UI. Therefore, as more data is added to an application and in cases where a new aggregation

needs to be performed, the CPU will be required to perform recalculations over larger slices of data, resulting in more required CPU cycles.

Figure 1 below highlights that as more data is added to an application, a uniform increase in both CPU and RAM capacity will ensure that performance levels are maintained to an acceptable level.

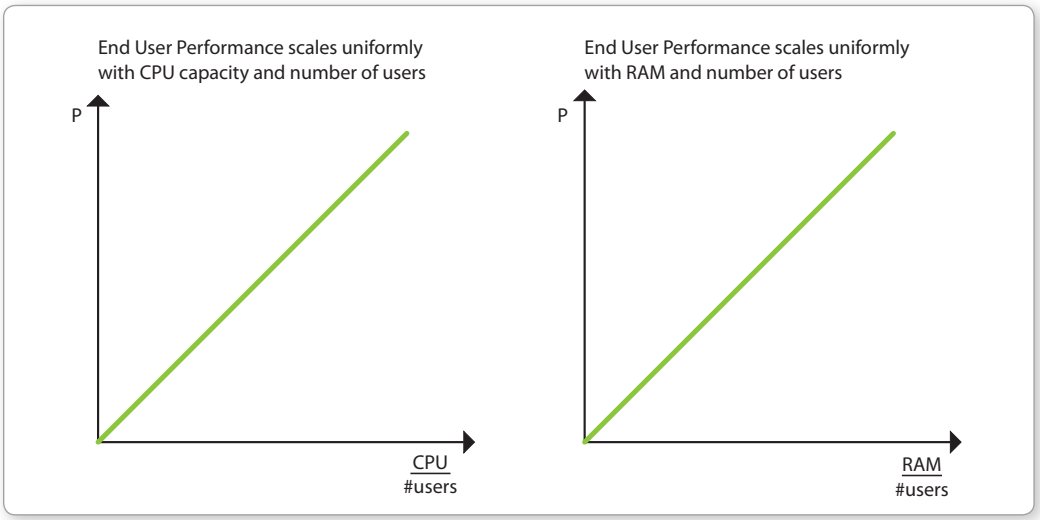


Figure 1

As will be seen from the section on application design, understanding the performance characteristics of any general QlikView application does not follow a simple formulaic approach, and as such one cannot simply state the 'upper limit' for the amount of data that QlikView can handle.

However, experience of many deployments has allowed us to provide a rough calculation of the RAM needed for a given source data size and expected usage numbers. Please note that this calculation should be treated as a generalized, averaged estimation for the purpose of illustration.

$RAM = (RAM_{user} \times \text{No. users}) + RAM_{initial}$

Where

$RAM_{initial} = \boldsymbol{QVWsize}_{disk} \times \boldsymbol{FileSizeMultiplier}$; this is the initial RAM footprint for any application

$RAM_{user} = RAM_{initial} \times \boldsymbol{userRAMratio}$; this is the RAM each incremental user consumes

$\boldsymbol{QVWsize}_{disk} = \boldsymbol{SourceData} \times (1 - \boldsymbol{CompressionRatio})$; this is the size, on disk, of a QlikView file

Assumptions:

userRAMratio: range between 1%–10%

FileSizeMultiplier: range between 2–10

CompressionRatio: range between 20%–90%

No. users is the number of concurrent users hitting a system, not the total number of supported users. Example:

SourceData	50GB
CompressionRatio	90%
FileSizeMultiplier	4
userRAMratio	5%
No. of concurrent users	30

$QVWsize_{disk} = 50GB \times (1 - 0.9) = 5GB$

$RAM_{initial} = 5GB \times 4 = 20GB$

$RAM_{user} = 20GB \times 5\% = 1GB$

Therefore, the RAM footprint to support 30 concurrent users in this deployment would be:

$RAM = (1GB \times 30) + 20GB = 50GB$

A more pragmatic approach is to understand the best practices techniques for using the various QlikView platform components to provide for a very large data size addressing while maintaining very fast user response characteristics. These techniques are detailed below:

LINEAR SCALING FROM A KNOWN DATA MODEL AND UI DESIGN:

A best practice approach to understanding how much additional hardware resources may be needed for any specific deployment when new data (and user numbers) are added to an application is to first measure the performance characteristics from a small deployment with a known, stable data model and a production-level User Interface. In most deployments where QlikView applications have expanded to accommodate very large data sets and/or user populations, the performance characteristics from the initial, smaller-scale deployment were examined as a 'benchmark' from which to extrapolate the data to determine the hardware requirements for larger deployments. This method has proven to be very successful and accurate. In every case, these deployments have shown to scale linearly with additional data (and user) loads. At a very simplified level, the steps are outlined below:

1. Measure the performance characteristics of a small deployment (i.e. measure end-user response times to new aggregation requests or new search paths).
2. Record the CPU and RAM usage in this environment.
3. Perform a linear extrapolation using the expected additional data and/or user loading on the application to determine needed additional RAM and CPU capacity.

INTELLIGENT DISTRIBUTION OF DATA: HORIZONTAL SCALING:

When it comes to handling expanding volumes of data, a best practices approach to breaking up and distributing data is preferable to trying to utilize a single QlikView application to store and analyze all data. Take the example of worldwide sales data: for a small company it might make sense to use just one QlikView application to analyze and present data from every country it does business in. However, for larger organizations this approach is impractical due to larger data volumes and larger number of users.

In these environments the QlikView Publisher product is used to take a source application (e.g. worldwide sales) and break it up into smaller applications (e.g. country-specific applications) which contain smaller data footprints. These 'reduced' applications are then accessed using clients via a QlikView Server.

Horizontal scaling refers to adding more server resources, either virtually or physically, to a deployment. QlikView Server deployments scale horizontally in a straightforward manner by adding new server machines and implementing a clustering and load balancing strategy. In the scenario depicted below in figure 2, one might have a single QlikView Server dedicated to each department, and each containing the relevant business applications pertinent to all groups within that department.

Using a horizontal scaling strategy in this way, end-user performance can be maintained or improved while scaling up to very large data needed for analysis.

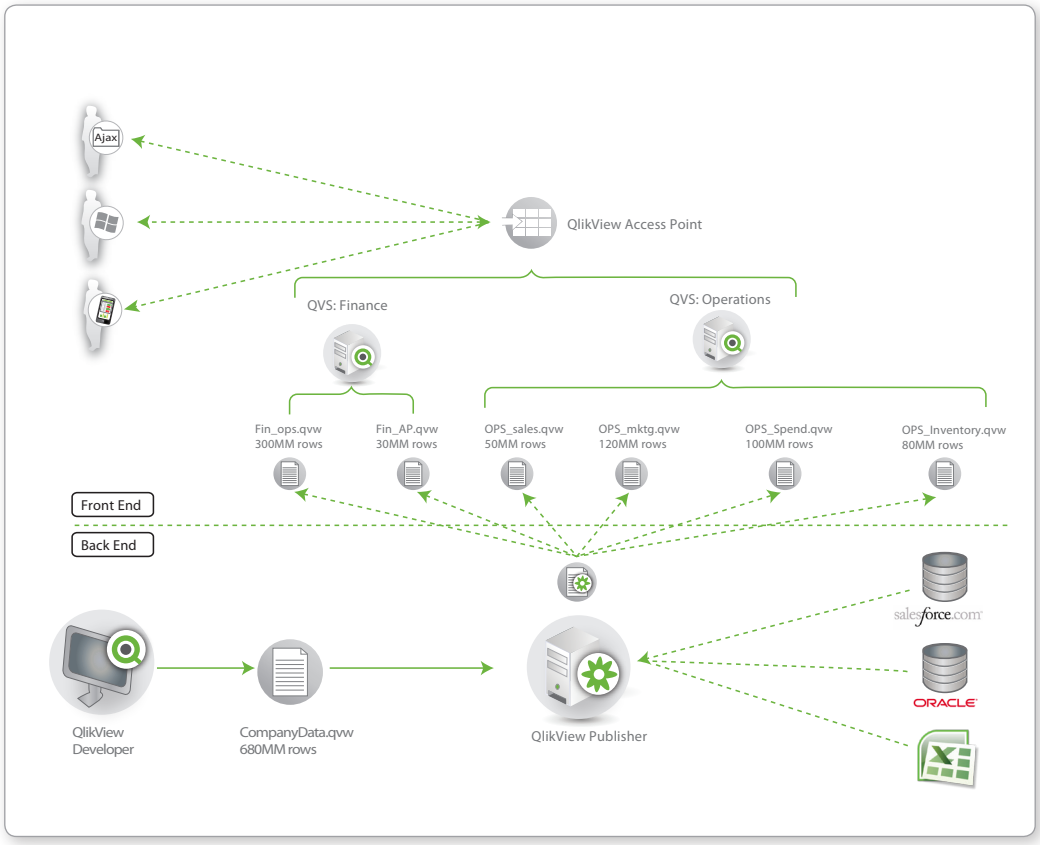


Figure 2

In addition, QlikView deployments support the notion of a multi-staged data architecture approach. This approach, when coupled with a horizontal scaling strategy is an effective means by which to scale up to many billions of rows of data, and beyond, while maintaining acceptable end user performance characteristics.

Figure 3 shows an example of a staged data architecture in QlikView. When combined, the total data being addressed by QlikView in this scenario might run into many billions of rows of data, however by employing a 'staged' approach to handling the data, and coupling it with a horizontal scaling approach, reliable end-user performance can be maintained.

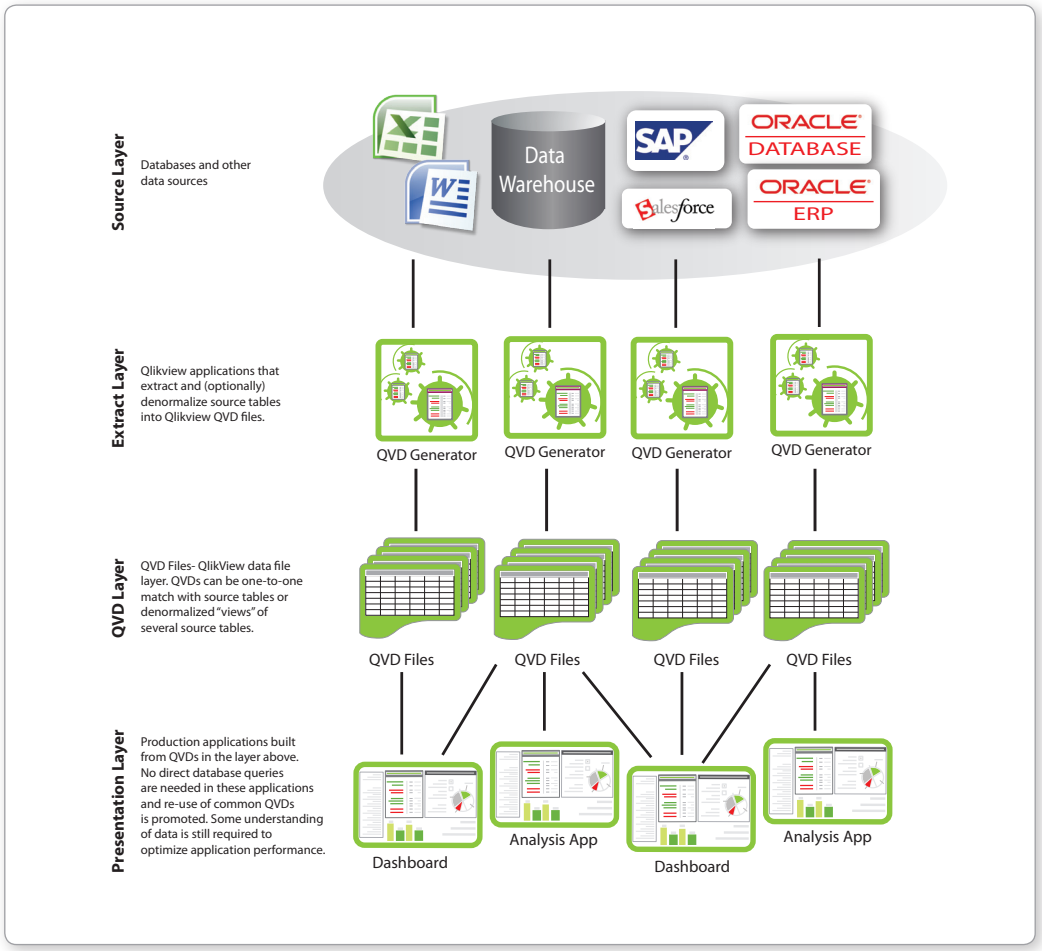


Figure 3

SCALING 'UP': VERTICAL SCALING:

Vertical scaling refers to the approach whereby more hardware resources (i.e. CPU and RAM) are added to the same machine to accommodate an increase in data and users.

Vertical scaling is a relatively more straightforward task than horizontal scaling (this document is not intended as a discussion of the merits of both), however QlikView deployments can take advantage of a vertical scaling of RAM and CPU capacity in a single machine to accommodate larger volumes of data. Again, this is a linear and predictable relationship: as more data is

added to an application, end user performance is maintained by the linear addition of RAM and CPU capacity to the machine.

INTELLIGENT LOADING OF DATA: INCREMENTAL RELOADS:

An effective strategy for dealing with increasing volumes of data is to employ incremental reloads. While this topic is more pertinent for a discussion on data modeling strategies rather than end-user scalability, it's worth mentioning here briefly as it highlights an important characteristic of actual deployed QlikView applications.

Incremental loads are when QlikView will only load - from source data - the newest data or latest transactions. These can be performed as part of the regularly scheduled reload process and are used as part of a multi-staged data environment that utilizes QVD files. The benefit of using incremental reloads is that data can be added to any given application far more quickly, limiting the amount of time needed for data refresh, thus providing end users with much quicker access to the latest data.

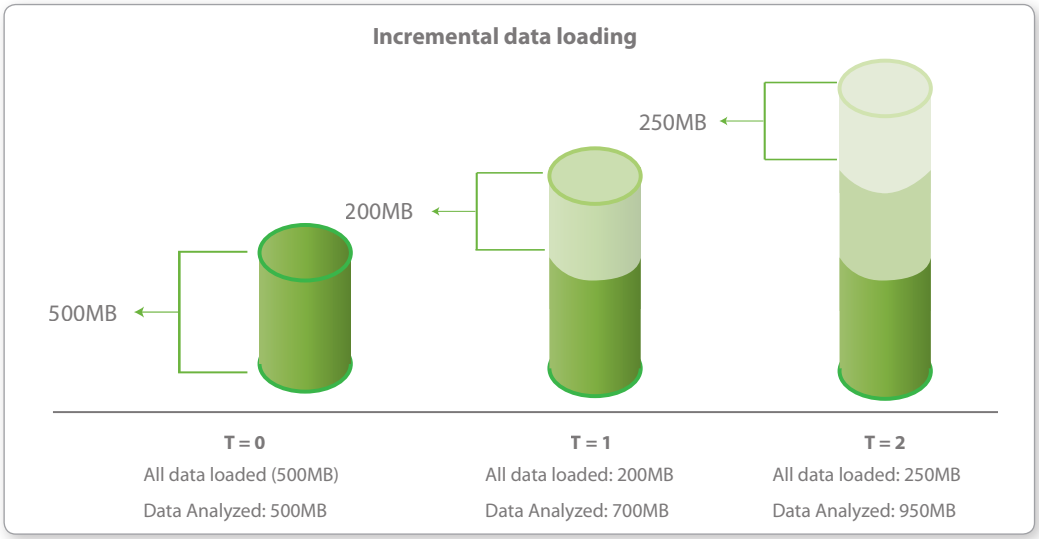


Figure 4

TECHNICAL CASE STUDY: LARGE APPAREL RETAILER, 70GB OF DATA:

When a large apparel retailer in the US Midwest needed a high performing, scalable business discovery platform, they selected QlikView. As a multi-channel retailer involved in both designing and selling men's and women's apparel, this company serves markets in multiple countries around the world, generating revenues in the many billions of dollars. Like many similar organizations, this company was challenged with their existing traditional business intelligence tools, growing frustrated with the lack of flexibility and the slow time-to-response from the business user's requests for new reports and fresh analysis.

The company chose QlikView to empower over 200 concurrent business users in inventory planning and forecasting to gain access to the over 500 million rows of data that simplifies their decision-making process.

Using a multi-tiered approach to their deployment architecture, QlikView Publisher resides within a secure back end and is responsible for taking 15 source qvw files to perform nightly reloads of data, total size of 70GB, from a variety of source databases including DB/2, Microsoft Excel and Oracle. Average nightly reload time is 4 hours. This is the beginning of the 'staged data' environment, where 5 qvd files of sizes varying 250MB to 60GB are created as intermediate data file stores. These files include data broken down by functional area and act as secure binary repositories from which the end user documents within the presentation layer extract data. The presentation layer is where the QlikView Servers reside. In this deployment, 4 QVS's were deployed in a clustered environment on 4 machines, 3 with 64 CPU cores and 256GB of RAM, and one with 32 CPU cores and 128GB of RAM, each running Windows Server 2003.

This company also engineered the capability to interface the mainframe scheduler into the QlikView Publisher so that in effect the mainframe scheduler triggered QlikView tasks based on file availability on the mainframe.

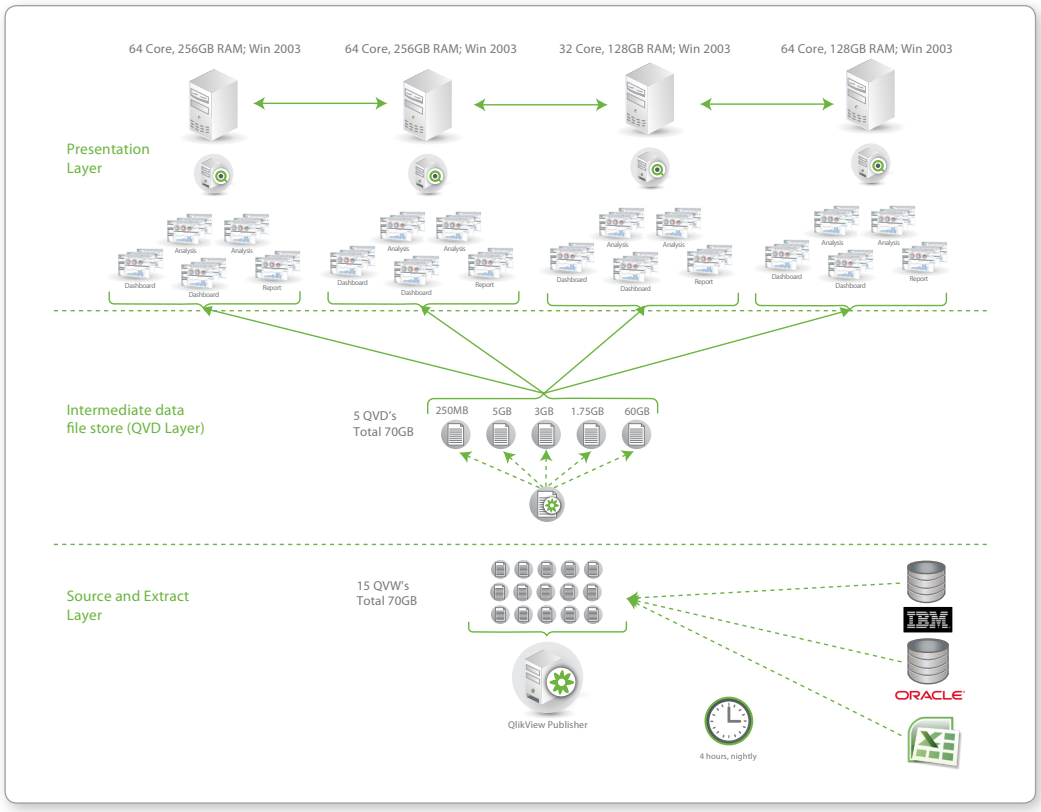


Figure 5

Number of Users

As companies grow, the demands on all IT infrastructure assets increase as a result of more people needing access to IT applications and resources. QlikView applications are no different. Not only have we seen increased user demand on deployed applications because of company growth, we've also seen significant demand increases as adoption of a QlikView solution takes hold within an organization.

IT departments are tasked with understanding the scaling characteristics of their applications and need to know that their vendors' solutions will respond predictably and proportionally to increases in hardware resources to accommodate the new demand.

THE QLIKVIEW APPROACH:

Fundamentally, it's important to note that QlikView's performance scales uniformly with user loads.

As has been seen with all deployments, as new users are added to an existing system, the performance impact is predicable and proportional and can be addressed by the addition of more resources such as CPU capacity and RAM.

As was stated in the preceding section on data scaling, it's important to understand the impact that adding both CPU capacity and RAM will have in order to maintain optimal end-user performance as more concurrent users stress the system.

Again, QlikView utilizes an in-memory data store in which all data that is analyzed in any given QlikView session will reside. As noted in the QlikView Architecture and System Resource Usage Tech Brief and in the RAM calculator in the Size of Data section in this paper, when the first end user opens a QlikView document, the amount of RAM needed is usually between 2x – 10x the size of the application on disk. This is to accommodate overhead such as indexes, data associations and so on. The addition of concurrent users causes more RAM to be allocated. Even though core aggregations are shared across all users by means of a central cache, each individual user requires his/her own session state, which requires additional RAM to be allocated.

As was seen in the QlikView Architecture and System Resource Usage Tech Brief and in the RAM calculator in the Size of Data section in this paper, a general rule of thumb can be used for estimating the per-user additional overhead associated with new concurrent users (i.e. add 1-10% of RAM above that used by the first user).

> *For example: A 1GB .qvw document uses around 4GB in RAM for the first user (based on a multiplier factor of 4). User number two may increase this by around 10% as their calculations get cached, resulting in a required RAM footprint of 4.4GB. User number 3 requires a further 10%, increasing the footprint to 4.8GB, and so on.*

As is discussed in the QlikView Architecture and System Resource Usage Tech Brief and also in the later section on Application Design in this paper, it's important to note that the density of the data and the data model structure, along with the UI design contribute significantly in the determination of the overall RAM footprint

In summary, a properly designed QlikView application will not take up more than 1% to 10% of the RAM usage for each additional user after the first.

CPU capacity needs to also be considered when expecting an increase is concurrent user loading. As stated previously in the QlikView Architecture and System Resource Usage Tech Brief, CPU cycles are used whenever a user makes a request in the application for a new aggregation, new drill-down path, redraw of the UI based on a new chart interaction and so on. As a result, CPU capacity needs to be added when more concurrent users are expected. As will be seen in the section covering the Scalability Center results, end-user performance can be maintained with the addition of processing capacity (and a corresponding increase in RAM).

Figure 6 below highlights that as more concurrent users are requesting access to an application, a uniform increase in both CPU and RAM capacity will ensure that performance levels are maintained to an acceptable level.

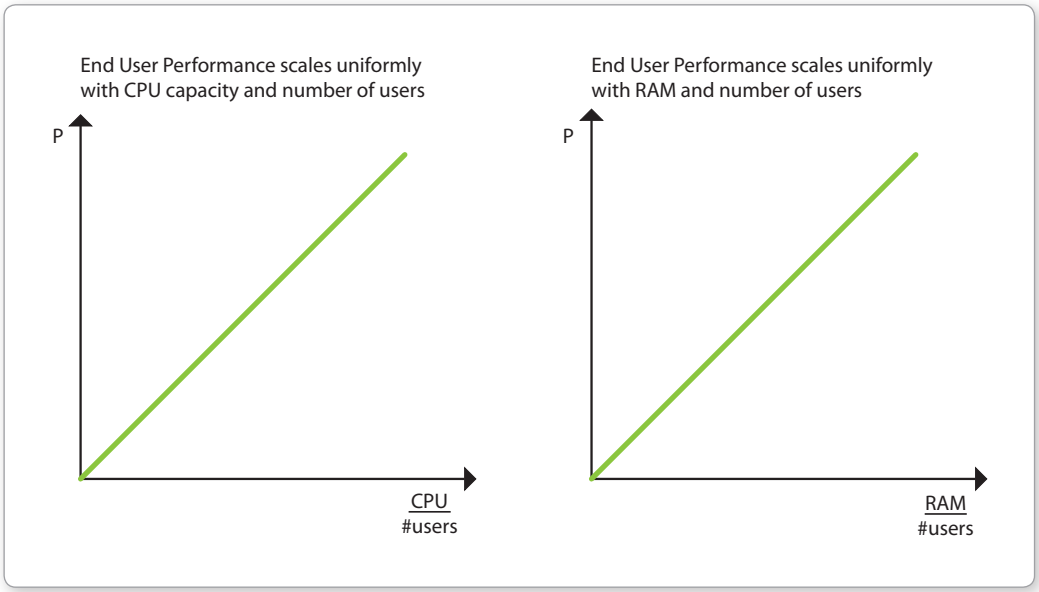


Figure 6

As an increasing number of users make requests to an application with a finite number of cores or CPU's available, performance degradation naturally occurs. This is most commonly offset by adding more processing capacity by scaling horizontally using a clustering and load balancing technique.

CLUSTERING AND LOAD BALANCING:

Clustering refers to the ability to link multiple servers together within a single entity called a 'cluster'. Load Balancing refers to the ability to distribute and share resources (e.g. processor capacity and memory) across the cluster in an even and defined way.

Clustering and load balancing are effective techniques for scaling up the number of users who need to use a QlikView application without a corresponding reduction in end-user performance. A QVS cluster (which uses QlikView AccessPoint as the load balancer) will automatically apportion a new user request to a server that has a lower current resource demand (i.e. lower processor usage or memory usage) so that the user's experience can be maximized. It is achieved by simply adding servers into a QVS cluster. It also ensures very high availability for users as automatic fail-over is another component of a clustered QlikView Server environment. Figure 7 below shows an example of a typical QVS clustered environment.

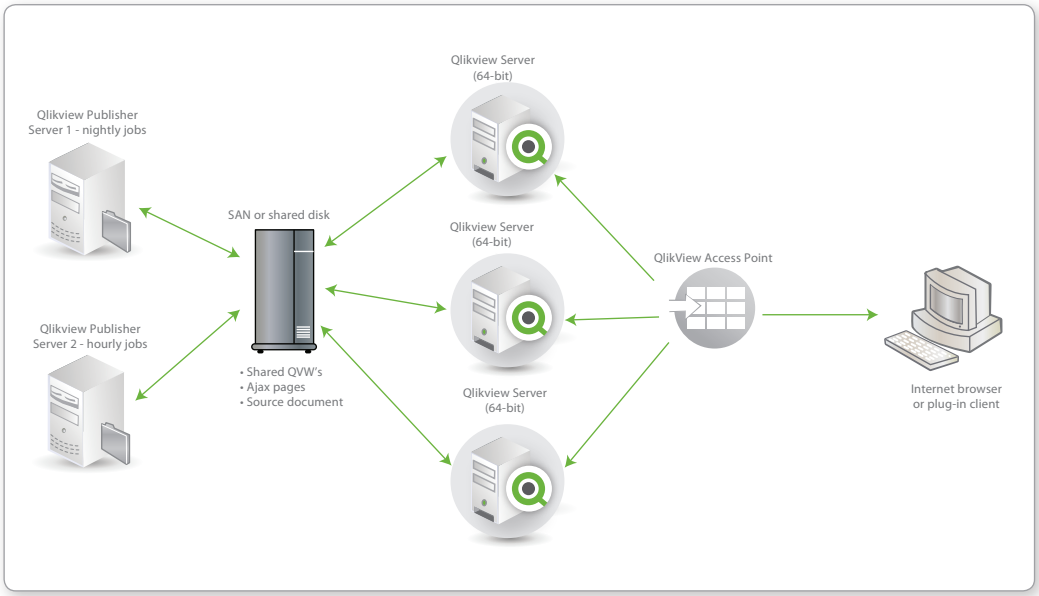


Figure 7

TECHNICAL CASE STUDY: LARGE MIDWESTERN MANUFACTURING COMPANY: MORE THAN 8000 USERS:

When a major manufacturing company in the US Midwest needed a high performing, scalable business intelligence platform, they selected QlikView. With billions of dollars in worldwide sales, thousands of innovative products used in dozens of diverse markets, in multiple countries around the world, and with thousands of employees, this company was challenged with their current business intelligence tools, inflexible Six Sigma project demands and a need to provide product margin analyses. With an increased need to show responsiveness to business demands, the organization deployed QlikView to more than 8,000 users across many functions.

Drawing data from Teradata, SQL Server, DB2 and Sybase, the company now uses QlikView for sales analysis, supply chain analysis, IT analysis, and Six Sigma analysis.

15 production QlikView Servers are used (with 4 development servers), and 11 QlikView Publisher instances handle all data reload and distribution tasks.

There are many hundreds of QVWs in production. The most widely used is the application for sales analysis and reporting for reps in the field. This application is looped and distributed to 8,000+ agents every Monday morning. It is tied to an Active Directory database with over 400,000 employees in it. Largest QVW is 600MB on disk.

For the sales analysis and reporting needs, the company takes two master QlikView documents in the 500 MB range (on high compression), loads 500 million rows, 300 columns of data and creates 1,800 user documents through QlikView Publisher during the weekend, with 400 documents run daily, the largest of which is 1.1GB on disk and contains roughly 40MM rows.

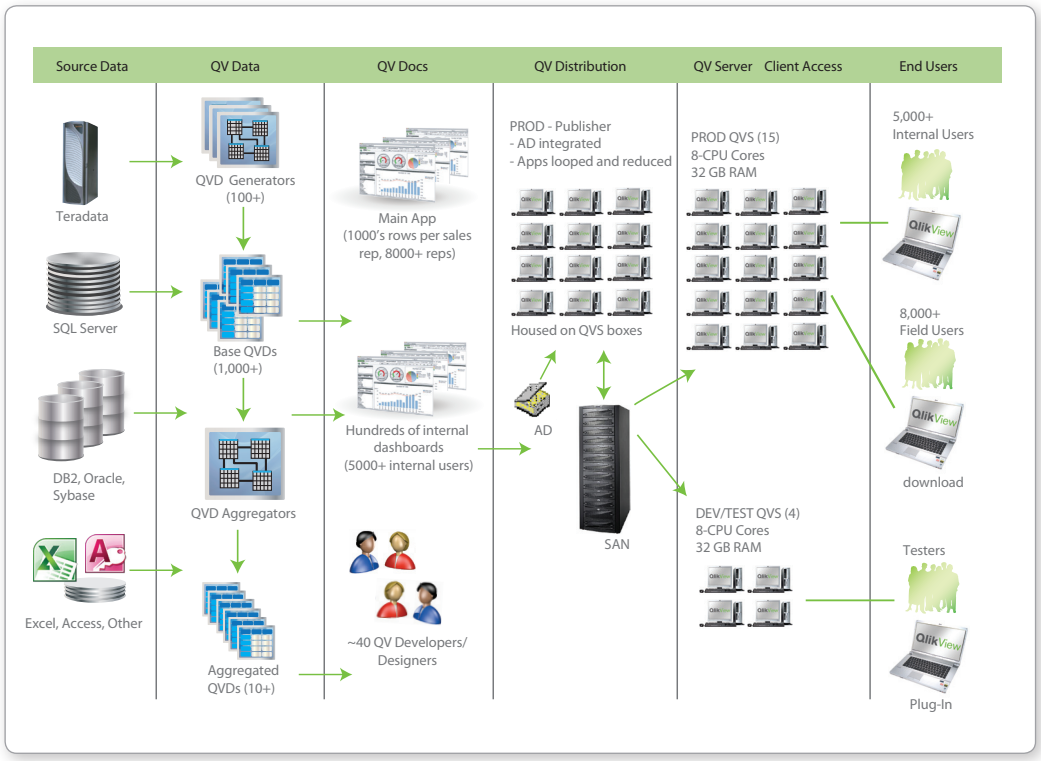


Figure 8

Number of Applications

In many cases, QlikView deployments start out small in nature, typically in one department and containing one application, but quickly grow quite large as companies see the rapid return on investment of QlikView's approach to BI. Other departments start creating their own applications and soon there can be hundreds of applications spanning multiple departments in multiple geographies. Additionally, even within single departments, as adoption rates increase, a more diverse set of people need access to the data, necessitating the need for more varied applications. This puts increasing demands on IT in a variety of dimensions, some of the most critical being how to handle data load demands (from source databases), data management, user management, and so on.

THE QLIKVIEW APPROACH:

It's important to understand the definition of an 'application' used for this section. In general, an application is a QlikView file that either a) is used by an end user to analyze, visualize and present data – known as a .qvw file - or b) is used as a 'headless' (i.e. UI-less) optimized application containing data– known as a .qvd file. In both cases, an application contains data extracted from original data sources such as a database or flat file.

As companies grow out their footprint of QlikView applications, it's important for those responsible for the deployments to employ a multi-tiered data and application architecture approach.

Let's take a look at an example:

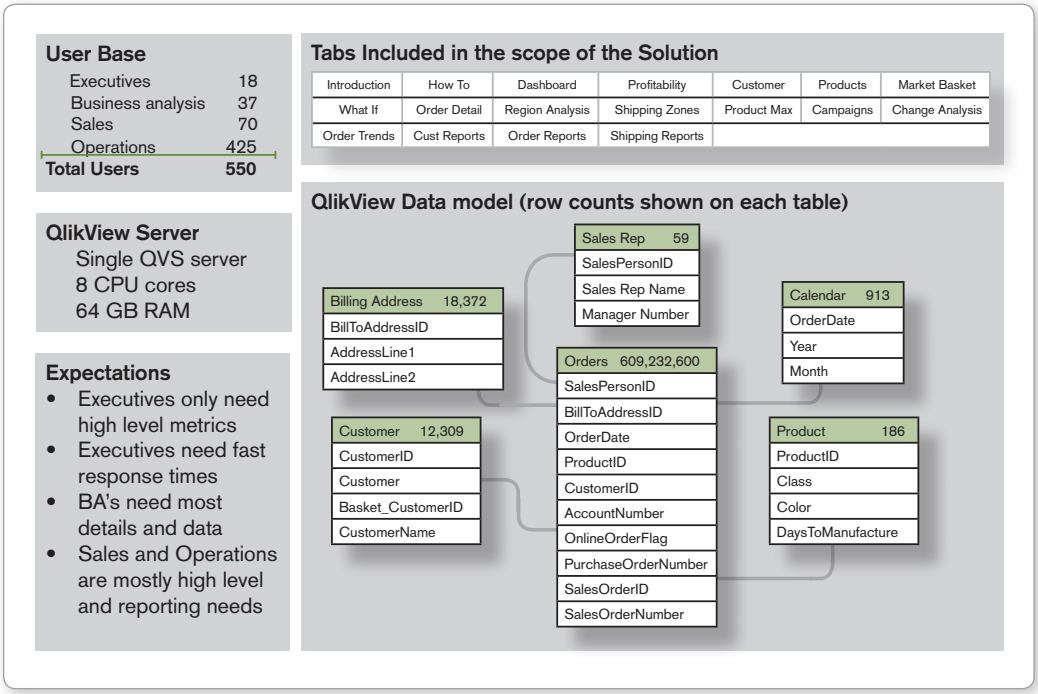


Figure 9

The scenario outlined above is for examining a company's sales data. The organization has various demands in terms of requiring access to the data, in various degrees of granularity and specificity. Below is a graphic depicting the deployment:

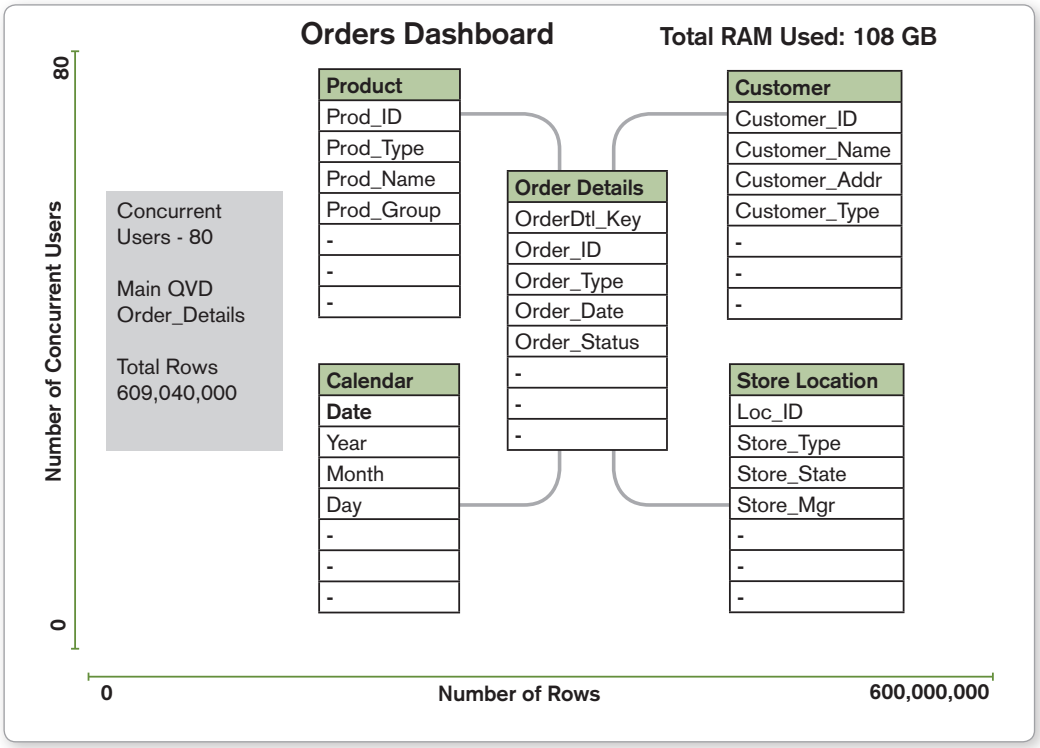


Figure 10

In this deployment, the company has a total user base of 550 individuals, spread out across both business functions and role. The data contains over 600 million orders records as well as customer, store, product, sales rep and date data. The company wants to provide executives, sales and operations with an aggregated dashboard view of the data, but also wants to provide business analysts with more granular access to the data for detailed analysis.

SCENARIO 1: ONE SINGLE APPLICATION COVERING ALL USE CASES:

This scenario includes a single QlikView document called Orders Dashboard, which contains all subject matter in the data model across all 609 million rows of data. This would be a very large document and would provide the worst performance of the scenarios presented here.

The advantage of this approach is that it is easy to develop, however this would be the hardest to performance tune to meet the executives' needs and also drill down to the transaor ctional details that the business analysts sometimes need. Since the footprint of this application would be large, less capacity for concurrent users would be supported than some of the subsequent scenarios.

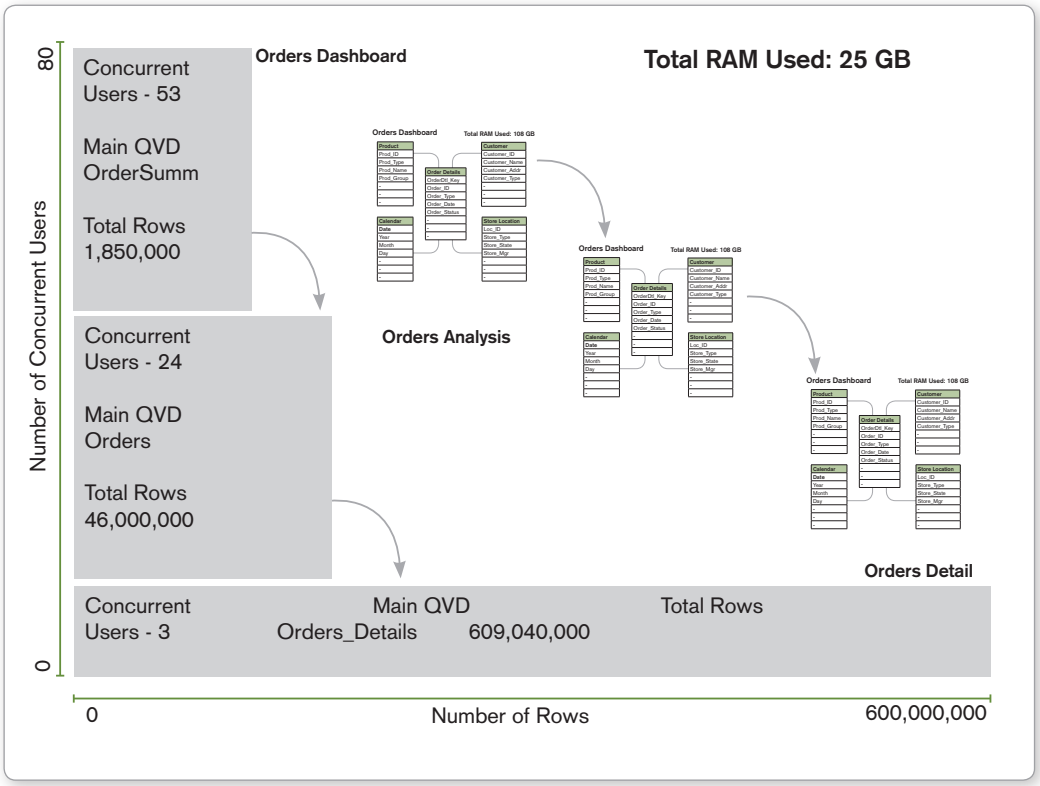


Figure 11

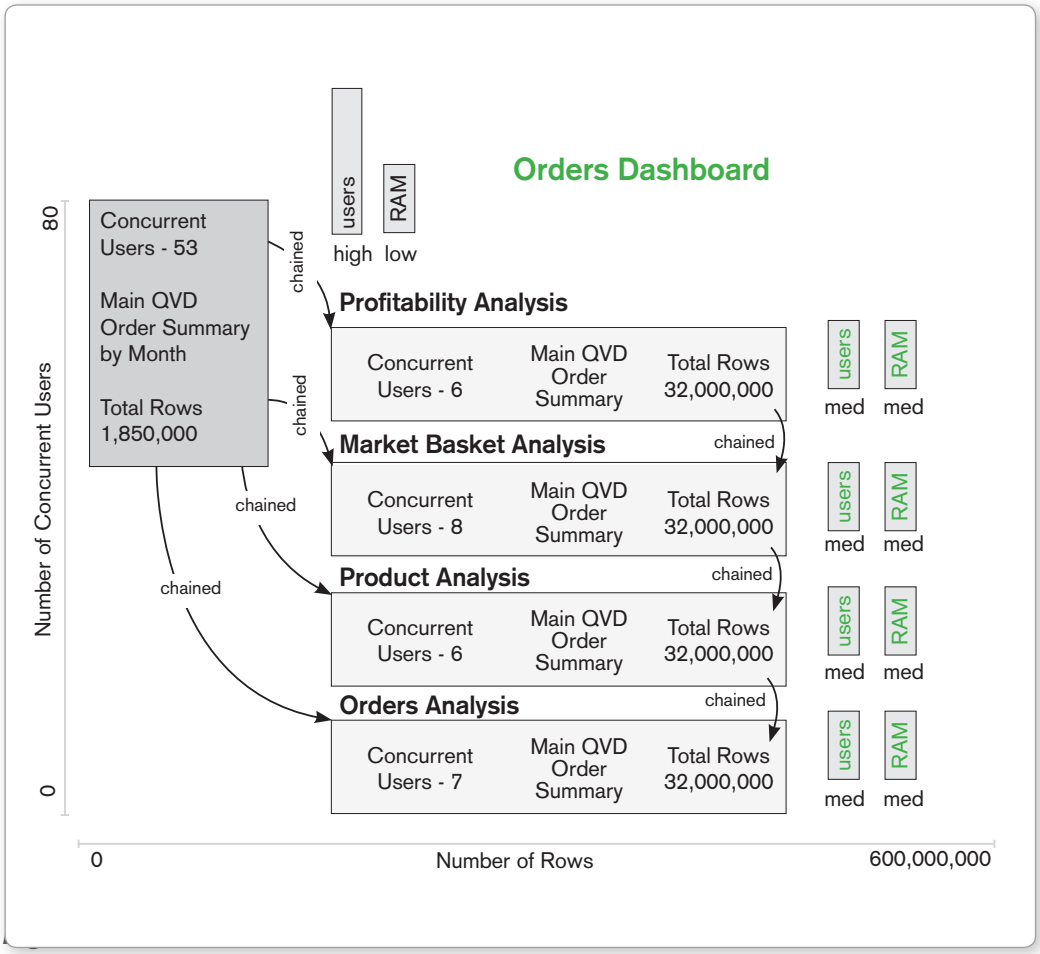
SCENARIO 2: 3 APPLICATIONS SEGMENTED BY DETAIL:

This scenario, seen in Figure 11, includes three.QlikView documents called Orders Dashboard (1.8 million rows), Orders Analysis (46 million rows) and Orders Detail (609 million rows). The data model for these QlikView documents would be almost identical, though the granularity of the data would differ drastically. Notice the concurrency volume of users goes down as users drill from the dashboard to the analysis app and then again down to the details app. This is a normal distribution pattern for segmented documents.

The advantage of this approach is that this supports a higher concurrency, since the smallest app is in memory with the most instances. It also has a high performance since the smallest application is the fastest.

SCENARIO 3: 5 APPLICATIONS SEGMENTED BY SUBJECT:

This scenario includes five QlikView documents. The first one is the dashboard (5 million rows), and the next four are subject oriented analysis applications, each having 50 million rows. The data model for the analysis applications would be very similar, but aggregated by different dimensions from the base data model. Aggregation of the four analysis applications could take place from a detailed set of QVDs, or the QVDs could be pre-aggregated and supplied to these analysis applications.



The advantage of this approach is that is supports a higher concurrency, since the smallest application is in memory with the most instances.

As can be seen from the preceding example, the number of QlikView applications can quite easily grow, according to the type of data that is needed to be analyzed, the user community doing the analysis and so on. It's important to construct a tiered data and application architecture. Figure 13 below illustrates an example 3-tiered mixed architecture to support growing numbers of applications.

Description:
This architecture includes the use of QVD files as a 2nd data stage, from which a QlikMart stage is built. This allows the presentation layer application to be basic binary loads from the QlikMart layer.

When to use:
Use this architecture when a short batch window is desired (QVD layer is fast) and you want to shield presentation app developers from having to build data models in a QlikView application. This architecture also promotes re-use at the QVD layer and the QlikMart layer, as layers can serve many different presentation applications. This helps support co-development of QlikView between IT and business teams.

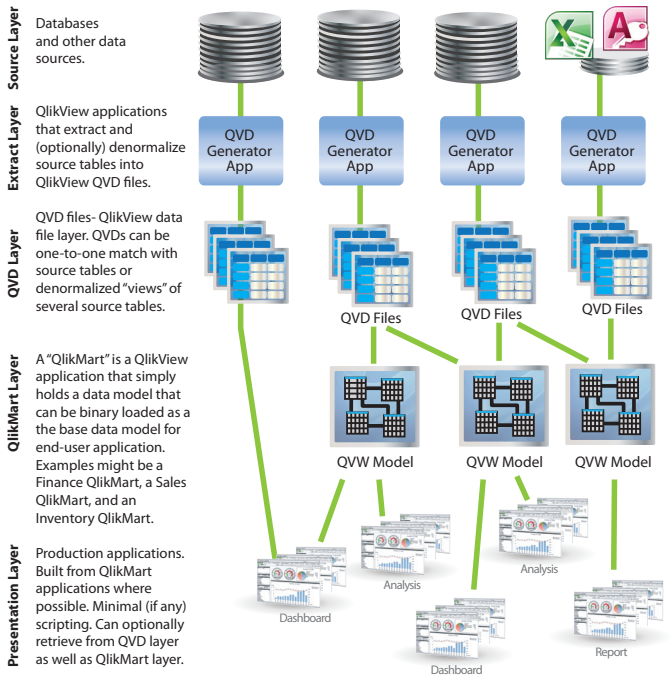


Figure 13

TECHNICAL CASE STUDY: SANDVIK: 50 MILLION ROWS, MORE THAN 100 DATA SOURCES, AND 3,000 USERS.

Sandvik, a leading tooling, materials technology, mining, and construction company, has more than 3,000 QlikView users across a large number of business functions including sales, pricing, purchasing, HR, and service. The company was first up and running quickly with an application to analyze customer profitability using data sourced from multiple systems. Sandvik now has more than 400 QlikView applications, the largest of which contains more than 50 million rows drawn from data sources that comprise terabytes of data. QlikView utilizes data from DB2, SAP BW, iSeries, Microsoft SQL Server, Oracle, text files, and a mainframe—more than 100 sources in all.

QlikView Application Design

As in many other aspects of life, bad design can lead to problems (or even failure) in production environments. For QlikView applications, this is no different. Of significant importance, from the point of view of scalability, is the design of the presentation layer (i.e. the UI). As with many similar applications, QlikView is responsive to how the UI is designed (e.g. what objects are used, how they are used and what the expected interaction model is) and consideration must be made for UI design best practices when looking at the challenge of providing a predictable user experience.

THE QLIKVIEW APPROACH:

While this paper is not an exhaustive study on UI design best practices, it's worth noting some factors associated with causing an application to perform inefficiently. It's important to emphasize the challenges associated with providing a blanket scalability 'formula' for all QlikView deployments because application design is such an important component in any system's performance as it is required to scale.

An application must be designed for its purpose. Application design covers a wide range of decisions and performance will depend on data model, expressions, unique values, number of objects, number of records, number of variables etc. Therefore it is important to consider performance at as early a stage as possible when starting up a new project. When considering larger implementation design characteristics, it's important to take into account (and monitor) the performance of the application (or applications) early in the implementation process.

In practice, it has been observed that two different application designs that might provide the end user the same value using the same drill path might differ in the demand for processing capacity when say, a pivot table is used rather than a statistics box, or when section access is used to employ security rather than server-side 'loop and reduce'. Because of these differences, it's important to create a benchmark application (with expected user interface design and general expected user interaction models) and measure the end-user response characteristics. From this benchmark, the expected hardware requirements to accommodate more users, data and/or applications can be extrapolated quite easily.

Even though QlikView scales uniformly by adding hardware, poor application design might lead to sub-optimal demands for hardware. By being thorough in the application design one can reduce the initial demand significantly and get much more performance for the hardware footprint.

Some examples of design factors that should be considered when optimizing an application for performance:

- Avoid using too many listboxes on any given tab.
- Do not overuse Table boxes and Pivot tables.
- Avoid repeated use of large expressions within a visualization.

- Avoid use of macros.
- Avoid overuse of variables for UI expressions. Each variable needs to know which one is calculated first. It is best practice to move some of them into the script as 'fixed' values at the time of reloads.
- Avoid using many text objects with complex calculations: use a chart to display the similar metrics (e.g. mini chart).
- Avoid using the function *date(Now)*, rather use *today()* if today's date is needed. *Now()* will recalculate every second of the day.
- Avoid using too many distinct text values in a field, which will increase the size of the file, thus slowing performance. For example: Separate phone numbers with area code into separate fields (i.e. use (212) and (555-5555) rather than (2125555555)). Divide addresses into separate fields, not combined together.
- Do not hold non-necessary fields in memory if not used or not needed in the future. Avoid select * but pick the fields that are needed.
- If a table contains large amount of records, give a calculation condition to narrow down the selection before viewing it, if possible.
- (See section on Size of Data scaling): If it is not necessary to distribute an entire application, perform a loop and distribute using QlikView Publisher (e.g. per region or department) so that each application is smaller.

IMPACT OF UI DESIGN DECISIONS ON RAM USAGE:

Characteristics of User interface Objects Created

Salesperson	Total Sales	Cost	Margin	Margin %
Tina	$900	$600	$300	33%
Tom	$600	$200	$400	66%
Teresa	$1000	$500	$500	50%

Figure 14

Depending on the definition of an object the amount of RAM required to draw the object can vary drastically. For example the chart above displaying the dimension 'Salesperson' would take a tiny amount of RAM to draw assuming that there were only three salespeople. However, if the application designer were to change the dimension to 'product', say, and there were 13 million different product SKUs listed in the database, then drawing that object could take a significant amount of RAM.

Even non-aggregated data takes up RAM to display. For example a listbox with 50 million records in it would be expensive to draw. This is especially true of tableboxes and other detail level

objects. For example if the following five fields are used in a tablebox - Salesperson (3 distinct occurrences), Region (3 distinct occurrences), Customer (200 distinct occurrences), Date (3652 distinct occurrences) and Order ID (50 million distinct occurrences) then you have created a structure that will require 250 million cells to be stored in memory (the # of records in the most granular field – 50 million – times the number of columns – 5). This object will be quite expensive to display. Best practices would dictate to not use this object or to conditionally suppress it until selections are made to limit the number of records to return.

NUMBER OF USER INTERFACE OBJECTS VIEWED

When a QlikView application is opened, all visible (i.e. not suppressed, hidden, or minimized) charts and objects are calculated and drawn, taking up a corresponding amount of RAM. The more sheet objects visible, the more RAM used to display them all and the more CPU required to calculate them. Even objects that have never been visible and never shown take up some RAM simply by virtue of being defined in a QlikView document. For example all the objects on a hidden sheet will still take up some RAM. This is a smaller subset of the amount of RAM that would be needed if the object was to be drawn but some RAM is still used in documents.

CACHED AGGREGATIONS

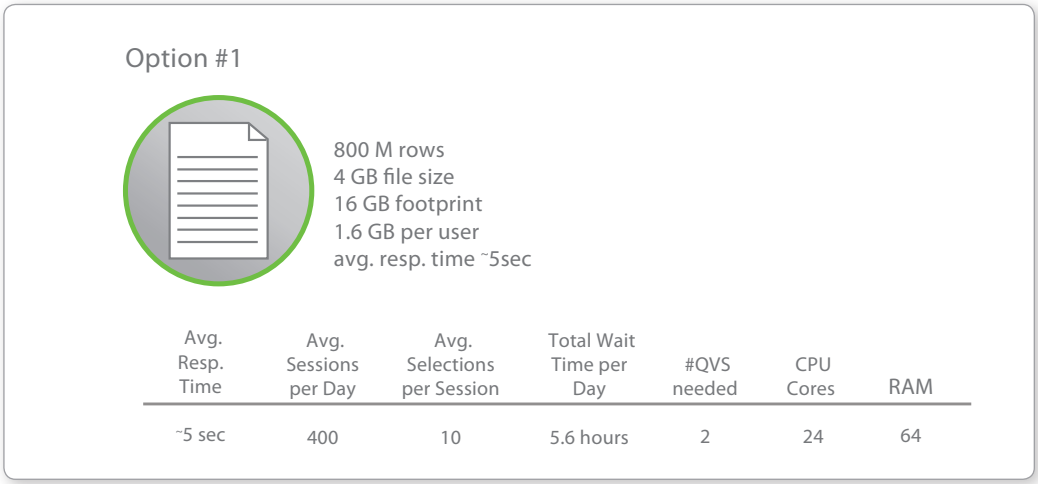
Once an object has been viewed the aggregates are cached in case they are needed again. This will improve performance for chart calculation time at the cost of RAM to cache this information. The caching of data is also done by selection state so that the representation of the same chart with different sets of selections is cached as different selections are made within the document. Unlike the RAM used to draw user interface objects, RAM used to store cached aggregations can be shared between users so multiple users viewing the same charts in the same selection state can take advantage of the same cache.

Why Architecture Matters to Scalability

As has been discussed throughout this paper, much of the conversation about QlikView scalability centers around understanding and employing a best practices approach to architecture design and deployment. For example, it's important for IT professionals to have a good understanding of the approach that QlikView recommends to handle large data (i.e. using staged data environments, breaking up documents into smaller, more manageable and meaningful pieces, employing a multi-server environment and so on). The real-world examples below illustrate the reasons why being pro-active in the up-front architecture design can result in a much better performing deployment and better end-user experience.

SCENARIO 1:

A deployment has 800 million rows of data and a total user audience of 500 users. With a maximum concurrency of around 10%, this gives 50 maximum concurrent users at any given time. Initially (in Option 1), only 1 QlikView application was created to meet the needs of the organization and some performance tests were conducted.



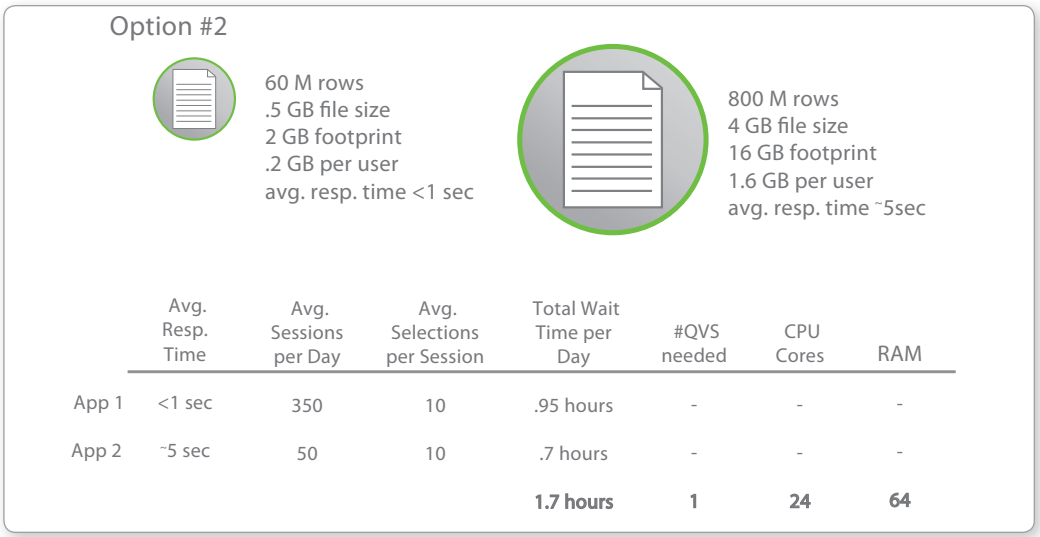
Avg. Resp. Time	Avg. Sessions per Day	Avg. Selections per Session	Total Wait Time per Day	#QVS needed	CPU Cores	RAM
~5 sec	400	10	5.6 hours	2	24	64

Figure 15

When aggregated, Option 1 contains a total wait time per day of 5.6 hours for 50 concurrent users, with an average response time of about 5 seconds. End user performance was deemed to be unacceptable, given the amount of RAM available in the system.

A second option (Option 2) was created, providing access to the same data, however making available to interested users a second smaller, aggregated-level application. (The organization recognized that not all of its users needed low-level detail information) The results are show in Fig 16 below.

It's clear that by employing a very simple approach to architecting the QlikView deployment (2 documents instead of 1; providing the appropriate level of data detail to the appropriate people) that end-user performance can be improved (~300% in this case) and less hardware is needed, even though the solution and data access being offered is the same.



	Avg. Resp. Time	Avg. Sessions per Day	Avg. Selections per Session	Total Wait Time per Day	#QVS needed	CPU Cores	RAM
App 1	<1 sec	350	10	.95 hours	-	-	-
App 2	~5 sec	50	10	.7 hours	-	-	-
				1.7 hours	**1**	**24**	**64**

Figure 16

SCENARIO 2:

Two companies have deployed QlikView, both of whom are addressing the same volume of data (~800M rows) and have the same hardware configuration (16 cores and 64GB RAM). Both also have similar overhead capacity when it comes to IT administration resources available to manage the deployment. However, by adopting a proactive and thoughtful approach to the QlikView deployment architecture, one company can service nearly 5 times the user capacity when compared to the other company.

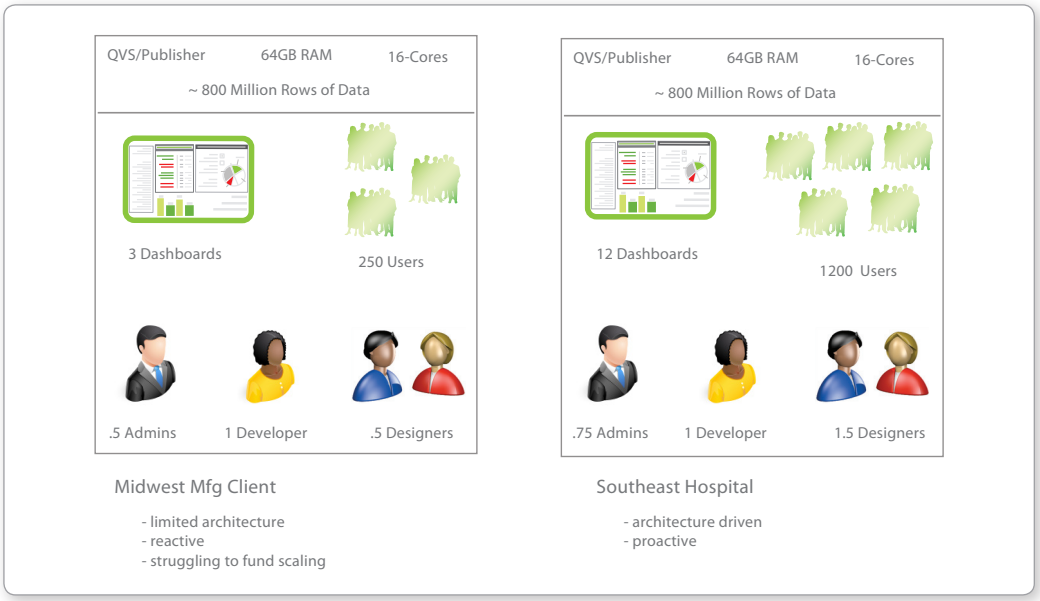


Figure 17

Both examples illustrate the effectiveness of conducting a proactive approach to architecture design when implementing a large QlikView deployment, and the payoff that can be gained in terms of end-user performance, hardware requirements and overall effectiveness of the QlikView deployment.

The QlikTech Scalability Center & Best Practices

QlikTech has a Scalability Center, which is dedicated to working on topics related to performance and scalability. The main focus is on handling larger amounts of concurrent users and applications covering larger data volumes. As part of the Scalability Center's offering there is a service for simulating realistic load scenarios of customer-specific applications deployed in the lab hosted by the Scalability Center. The benefit of this type of service is three-fold. Firstly, performance measurements for a broader scope of applications can be verified and the risk for forming conclusions based on customized and well performing applications is reduced. Secondly, there is a transparency on how QlikView documents are designed and utilized which in some cases can be transmitted directly to R&D as an input for product improvements. Thirdly, by offering customer sessions in the Center, customers can of course be provided with useful information on how their applications scale at larger deployments.

METHODOLOGY:

In the scalability center the server performance testing tool, JMeter, is used to script a user scenario and create a data load scenario. To replicate a realistic load mirroring real life scenarios, customer scenarios must be analyzed thoroughly. However, there are some assumptions and guiding principles that are used to create a replication of a real life scenario:

- Busy hour often occurs when a QlikView application has been updated with fresh data
  - Tests should be performed from a perspective when the QVS has been restarted and has an empty cache
- A typical user scenario can be simulated by predefining what objects that are likely to be used for drill down and what sheets that are likely to be of interest for a typical user.
  - Tests will have a pattern in what type of actions/clicks an average user is assumed to perform
- Each individual user is likely to have interest in different selections within any object
  - Test script will randomize any selection within a certain object (e.g. if a user is assumed to click in a Country object, users are assumed to be interested in different countries)
- A typical user will have a think time between clicks
  - Tests will implement think times between clicks. These think times typically varies dependent on what type of application and what type of users that are simulated
- An average user can be assumed to perform a pre-defined number of clicks. If the amount of concurrent active users should persist over a certain period of time new sessions must be initiated
  - When a simulated user performs its last action, this will trigger creation of a new session for a new user

With the methodology for creating a script as defined above, test executions and investigations from different perspectives are performed to make conclusions on how a certain QlikView

application performs under certain circumstances. It is important to understand that the results from any investigation on how QlikView performs is somewhat dependent on what the application design looks like and what user behavior has been assumed. Some objects may require a lot of processing to be calculated while others may not. How the user scenario (i.e. which objects that are triggered and how often) is implemented will therefore have an impact on the results. Each Virtual User (VU) generates a certain amount of clicks during its session. If there are short think times between clicks there will be a large amount of simulated clicks per time unit even with a small amount of concurrent VUs and vice versa. Therefore it is important to set realistic values on the following variables when performing customer benchmarking sessions:

- Concurrent Virtual Users
- Think time between requests
- Amount and type of clicks per user session

PRESENTATION OF SOME RESULTS OF INVESTIGATIONS FROM THE SCALABILITY CENTER:

Any performance result/measurement has a significant dependency on which particular application has been subject for the test session. It is therefore important to look for trends and not at any particular value when interpreting the results. Application design is one important part when it comes to improvements in performance. Another, common solution that at some point it is necessary is to upgrade the hardware. As discussed previously in this paper, there are several possible situations that might lead to an increased demand on hardware. When considering this, it is important to realize what a hardware upgrade is expected to deliver in terms of performance improvements. Let us distinguish between the following pre-requisites:

- An increased demand on number of concurrent users.
- Demand on improved response times.
- An increased amount of data.

Scaling with hardware can be done horizontally or vertically. Horizontal scaling means adding new servers in a cluster or via a load balancer. Vertical scaling means adding hardware to an existing machine. Which is the better alternative depends on the circumstances. The first thing to secure is that there is enough RAM available to handle a certain application with the desired number of concurrent sessions. As can be inferred from before, if a single application does not fit into RAM it does not matter how many small machines that are added to the server cluster. When it has been secured that there is enough RAM for a certain application one can start to scale horizontally or vertically to increase the capacity of number of concurrent sessions. In this section some investigations on how QlikView scales from different perspectives will be presented.

Apart from good application design one must also ensure that QlikView Server has the pre-conditions needed for delivering the great performance it is capable of. Server configuration is an example of such a pre-condition. The following section presents some best practices regarding server settings in larger deployments.

SERVER CONFIGURATION:

Extensive testing has been performed to verify how some of the more important server settings should be tuned for the hardware on which the QlikView Server runs. On average it has been concluded that the BIOS settings presented in Table 1 should be used for best performance. QlikView is not NUMA (Non-Uniform Memory Access) aware and therefore NUMA should be disabled for best performance. Enabling Node Interleave disables NUMA.

Variable	Setting	How to configure
Hyper threading	Disable	System BIOS setting
Node Interleave	Enable	Advanced BIOS setting
Hardware pre-fetch	Disable	Advanced BIOS setting

Table 1: *Recommended BIOS configuration for optimal performance of QVS*

Other settings that should be tuned for best performance are any settings related to power management as energy saving schemes will adversely affect performance. Power and energy settings should be set to high performance.

It is recommended to turn off performance logging in production servers, if not needed. Performance logging can be turned off from the Enterprise Management Console.

In the following sections discussing the results of the Scalability Center, the QlikView application that has been used for benchmarking is a retail application. Information about the application is seen in Table 2.

Data model	Number of records	Application size on disc	Application size in memory
Star	68 M	438 MB	1 GB

Table 2: *Statistics about the application used within this test session. Application size in memory measurements have been performed in idle state (i.e. prior to any load has been generated)*

RESULT 1: CONCURRENT USERS - SHOWING THAT QVS IS CAPABLE OF HANDLING MANY USERS:

As was discussed earlier, the theoretical number of concurrent users that a QlikView server can handle is dependent on the amount of CPU capacity available and how much memory a certain session corresponds to for a certain application. Typical values seen in the Scalability Center ranges from 1 to 10% of the application size in memory when caching is excluded. When handling a lot of concurrent users one can expect a high utilization of CPU capacity. When there is not enough processing capacity available response times will grow as requests are getting queued, waiting for service.

To demonstrate that QlikView is capable of handling many concurrent users when there is sufficient processing capacity and RAM available some tests have been run against a 12 core machine with 96 GB of RAM.

In Figure 18 it is seen how the number of active sessions increase over time as new VUs are added. When 1400 concurrent VUs have been reached the sessions persist just continuing to generate requests. In Figure 19 where the average response time for a selection has been plotted, it is seen how the response times can be seen as quite stable throughout the test session. Peaks for response times correlates with the average CPU (Figure 20), as expected. When all VUs have been initiated, a load of about 350 selections per minute is generated, see Figure 21. CPU reaches about 65% utilization on average during the busiest period for the server. Altogether this indicates that the investigated scenario for this application will run in a stable manner at the 12 core machine which has been used for this test session.

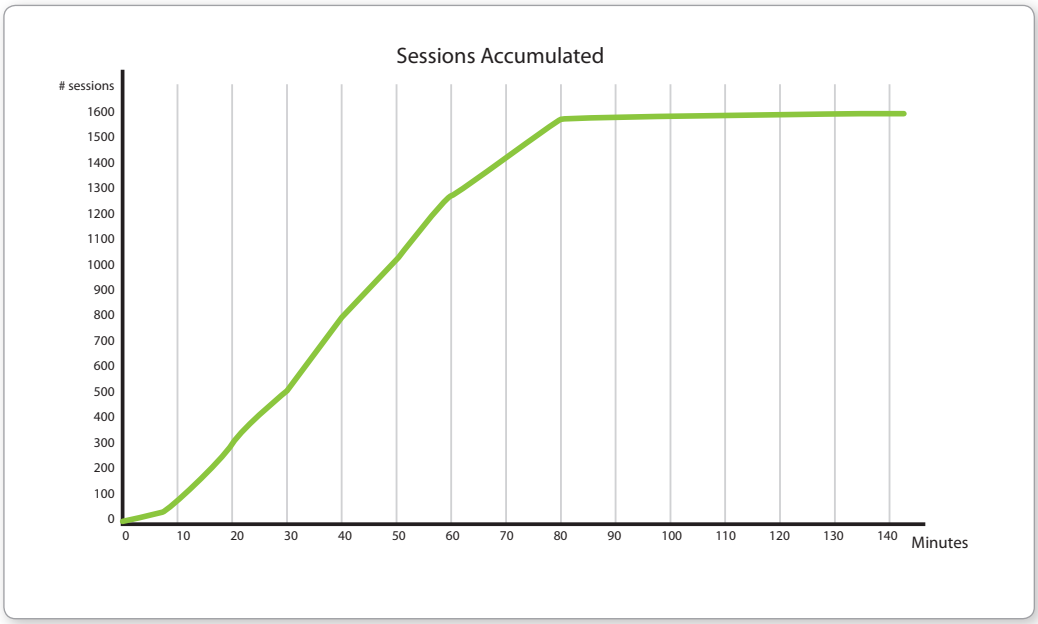


Figure 18: Green line shows the amount of accumulated sessions (i.e. concurrent VUs that are running) as new sessions are initiated.

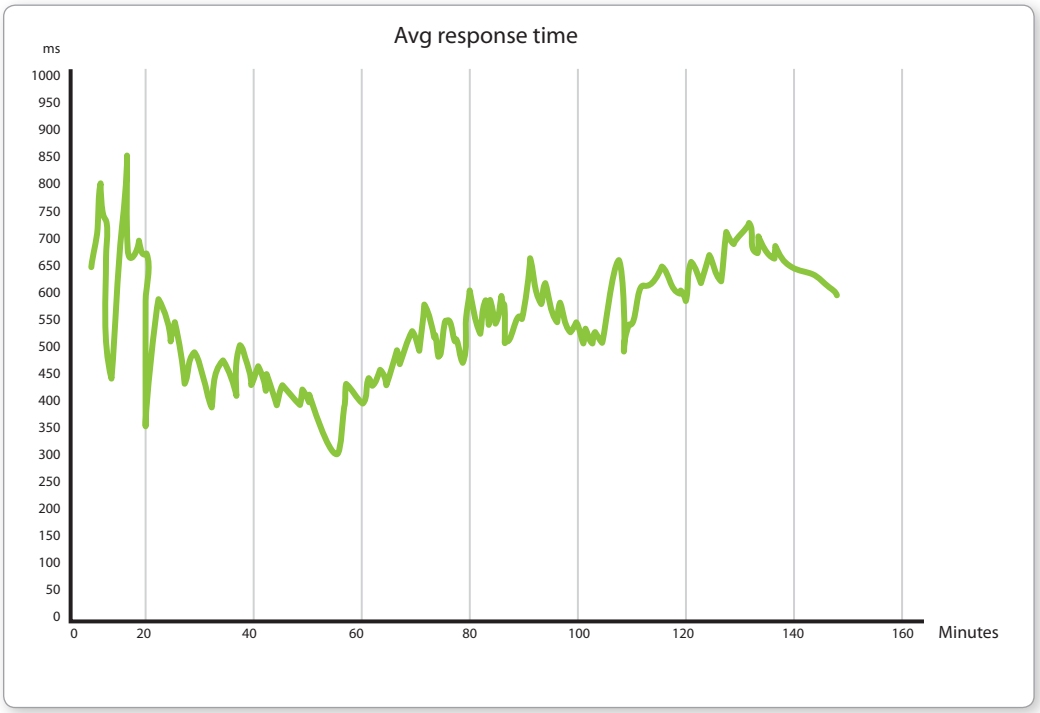


Figure 19: *Average response time per click (rendering not included).*

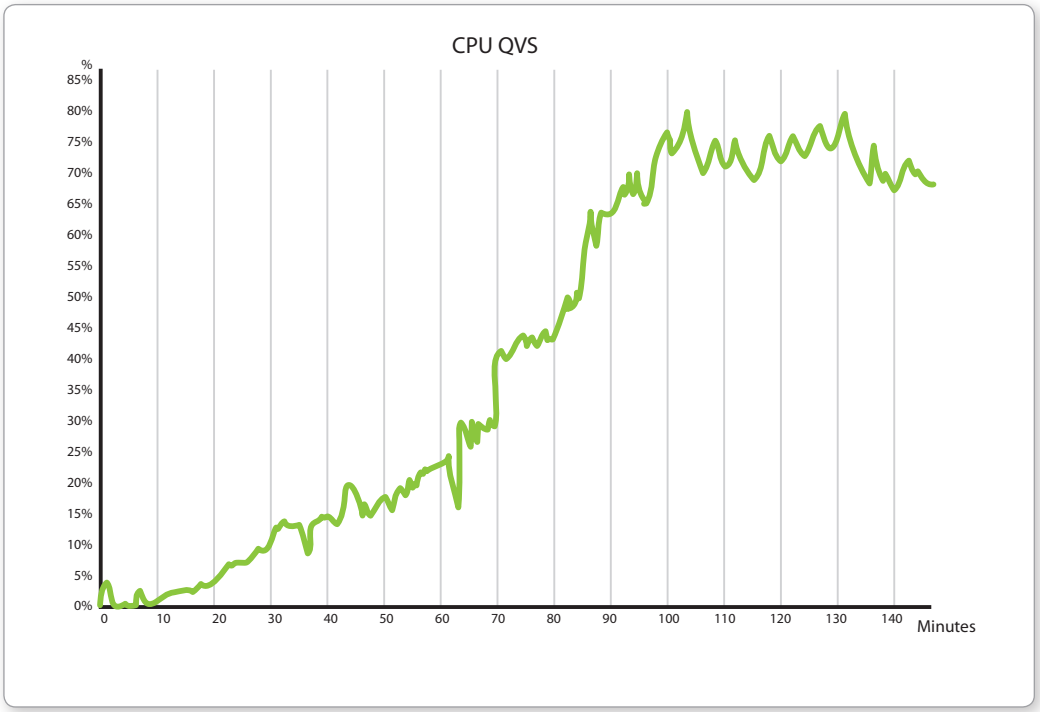


Figure 20: *CPU loading during the test session, measured with performance*

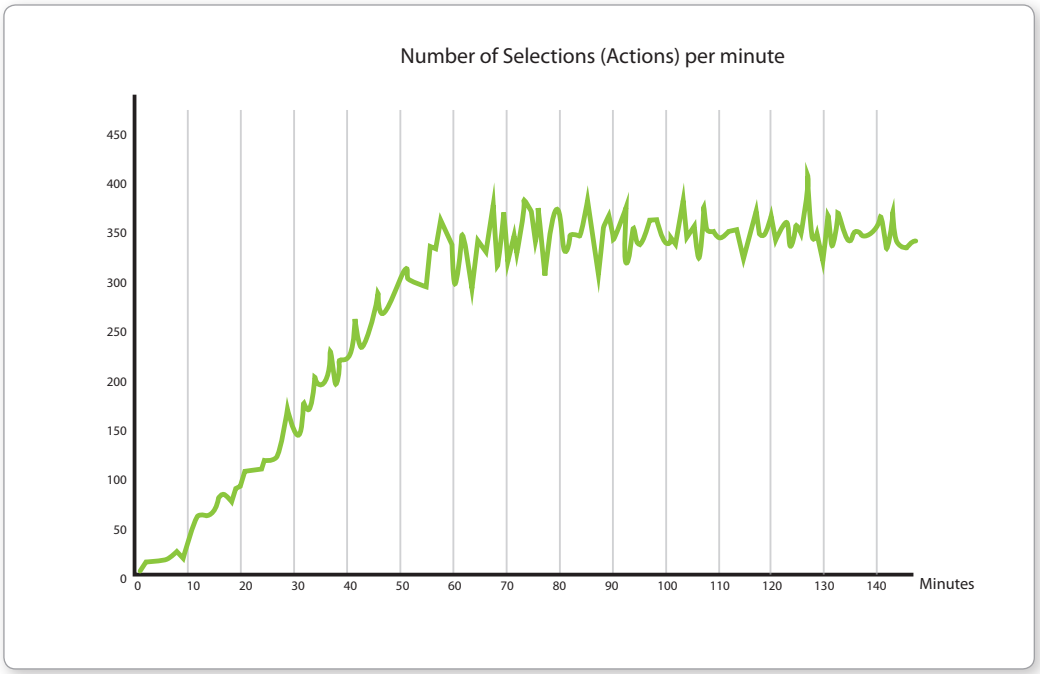


Figure 21: *Number of selections per minute plotted over time.*

RESULT 2: SCALING OVER CORES – SHOWING HOW QLIKVIEW SCALES UNIFORMLY WITH THE ADDITION OF PROCESSING CORES:

QlikView aims to utilize all available capacity for processing when there is something to calculate. When there are several concurrent requests for processing they will have to share the available CPU capacity, meaning that the response times will degrade. To maintain performance when there is an increased demand for processing or an increased amount of data, more capacity will be needed. To demonstrate how QlikView performance scales by adding processing capacity, tests have been performed during idle state and during higher loads.

Tests have been performed to validate how performance scales with the available amount of processing capacity on a Server. Tests are performed by single user idle state measurements to see how single selections scales over cores and by simulating many concurrent users generating load against the QlikView server to see how less demanding operations scales over cores. By enabling a different amount of cores during tests, it can be investigated how QlikView benefits by adding processing capacity.

The environment used for load tests have been dedicated for this purpose, and external factors (e.g. network variations) can be assumed to be negligible. Environmental setup during the benchmarking session has been a load client located at a separate machine communicating with the IIS web server running the same dedicated hardware as a single QlikView Server (QVS). The server used throughout this test session has 2 CPUs with 6 cores each, running at 3.33 GHz.

IDLE STATE TESTS:

During idle state testing, single selections have been performed manually against a rich QlikView application. Selections that have been performed correspond to heavy calculations and measurements have been performed for non-cached selections. Monitoring of server performance was mainly performed by collecting task manager statistics. The affinity configurations used in these tests were 6 and 12 cores.

LOAD TESTS SIMULATING MANY CONCURRENT USERS:

The same test script has been used throughout the test session. Selections/clicks simulated by each virtual user are described in Table 3. The script simulates 100 concurrent users with a think time between clicks of 4 seconds. The amount of processing capacity at the server has been tuned by changing the affinity for the number of cores in the QlikView Enterprise Management Console. The affinity configurations used in this investigation were 3, 6, 9 and 12 cores.

Step	Description
1	Open document, new session created
Loop start	Each session will loop its selections from this point 5 times. After 5 iterations a new virtual user will be initiated starting over at Step 1.
2	Change to sheet 1
3	Random selection from List box year
4	Random selection from List box month
5	Random selection from Multi box “upc”
6	Zoom random area in chart 1
Loop end	When the steps above have been performed the session will start over from step 2.

Table 3: Implemented scenario for each virtual user

RESULTS:

What has been observed is that as QVS scales with more cores then user response times will decrease in a very highly proportional manner with the addition of more cores.

LOAD TESTS SIMULATING MANY CONCURRENT USERS:

A test script has been run against the same server configured with different amounts of available cores. The script simulates 100 concurrent users that perform a click every 4th second. In Figure 22 the average response times for server requests have been plotted for the different configurations. A server request is defined as something requiring action from the QVS (with requests for static content excluded). It is seen how the response times decrease as the amount of available processing increases. Also the CPU utilization from the available cores is seen to decrease in Figure 23.

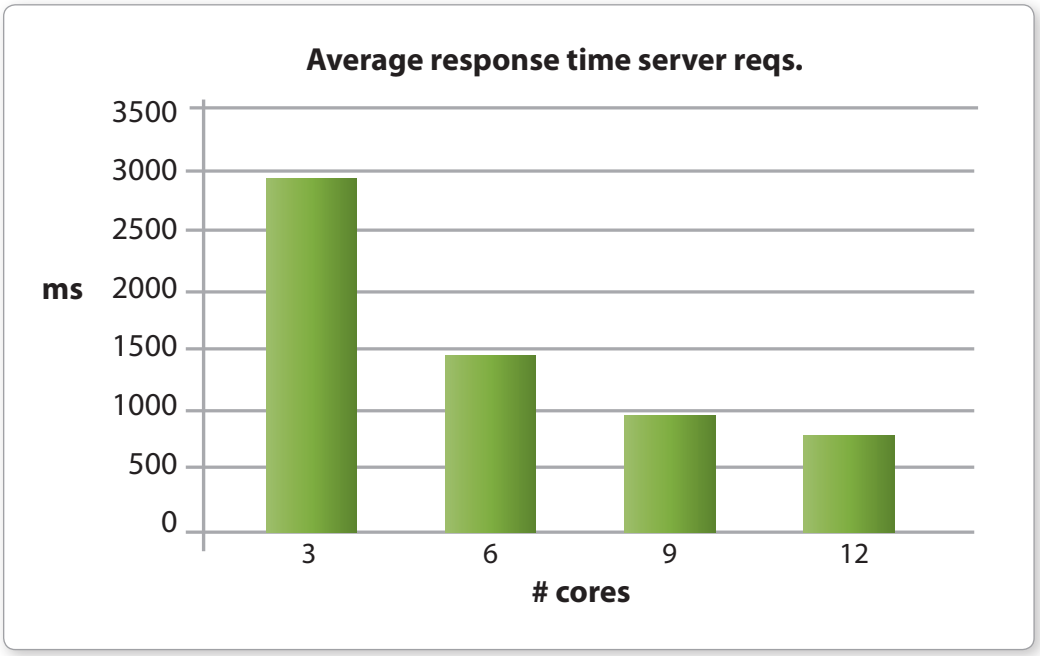


Figure 22: *Average response time for server requests.*

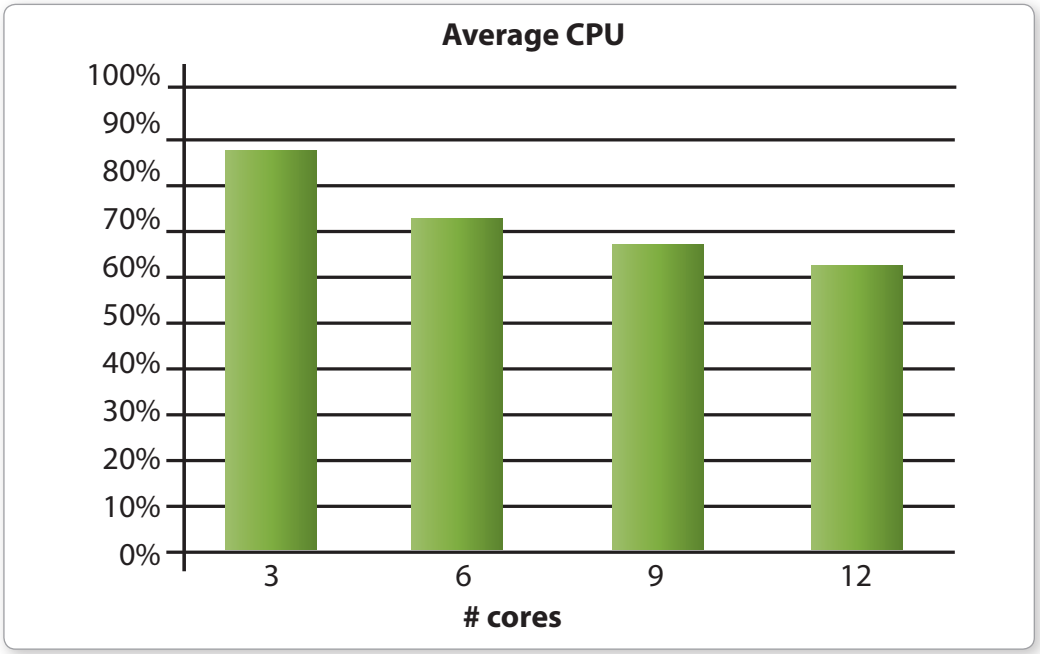


Figure 23: *Average CPU utilization for the different scenarios have been plotted where 100% corresponds to available amount of processing within configured amount of cores.*

The decrease in CPU utilization is not as significant as might be expected only considering the increased amount of processing capacity available to the application. However, this is caused by the implementation/design of the script. If a VU has a faster response time, the think time will still be 4 seconds. This means that VUs with shorter response times will generate more requests during the same period of time. Figure 24 plots the throughput as number of simulated clicks per minute for the 100 VUs.

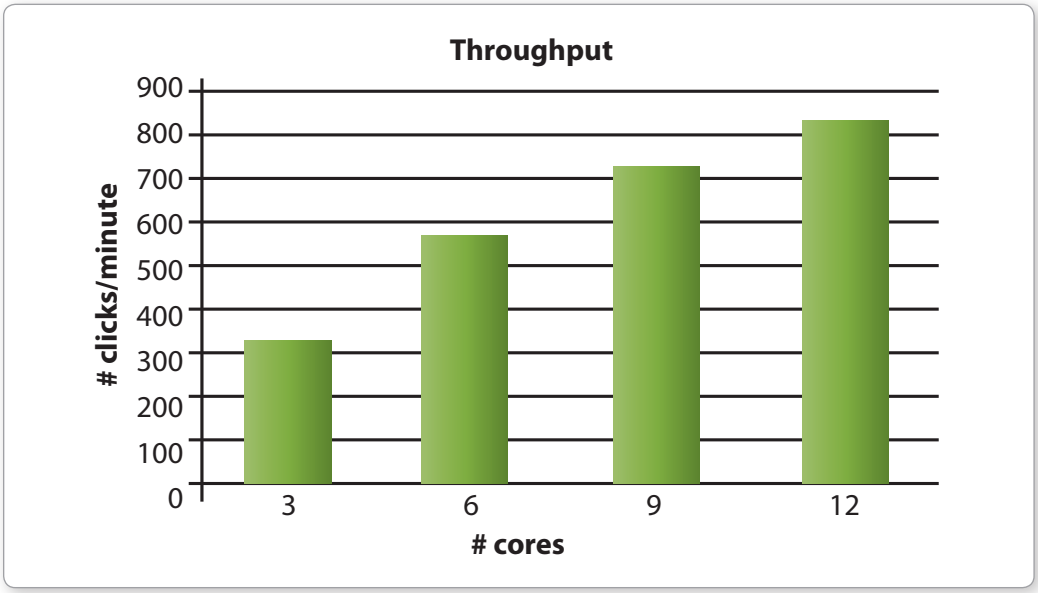


Figure 24: *Number of clicks per minute that have been simulated for the different test executions.*

It is seen how performance for the tested application with the simulated user scenario scales proportionally by adding more processing capacity. When dimensioning the hardware for a number of applications assumed to be utilized by a certain amount of users it is important to make sure that there is enough processing capacity for acceptable response times. It is a good thing that 100% CPU is utilized over short periods of time as this means that we will have shorter response time and better user-perceived experience. But one must make sure that the CPU utilization does not saturate on average, as this means that requests for processing are getting queued up, resulting in longer response times.

RESULT 3: PERFORMANCE AS A FUNCTION OF AMOUNT OF RECORDS:

TECHNICAL INFORMATION REGARDING THE TESTS:

The QlikView application used for benchmarking, populated with various amount of data, is a typical retail applications. The original document hosts data from 100 stores. The data model of the application is a star shape. The sizes for the variants of applications used within this investigation correlates with the amount of stores that has been included in an application, see Table 2. The Number of records variable corresponds to the amount of transactions that is included in the source data.

Application	Number of records (M)	Application size on disc	Application size in memory
10 stores	68	438 MB	1 GB
30 stores	168	980 MB	2.5 GB
50 stores	271	1.52 GB	4 GB
70 stores	315	1.77 GB	4.7 GB
90 stores	400	2.33 GB	6.4 GB

Table 4: Mapping of number of records to the different applications used within this test session. Application size in memory measurements have been performed in idle state (i.e. prior to any load has been generated)

The environment used during benchmarking was dedicated for this purpose, and any external factors can be assumed to be negligible. Further detail about the test environment is described in the table below.

Environmental	Attribute	Value
QVS	Version	9 SR7
	RAM	96 GB
	Cores	12
Web browser	Version	Firefox 3.6.15

Table 5: Environment used during test session

IDLE STATE ANALYSIS:

This section examines how the demand for CPU and RAM depends on the number of records. The applications described in Table 2 have been used for reference measurements. The amount of required CPU seconds to fulfill the calculations for a certain object will be dependent of what type of calculations that are requested and how many records a certain calculation involves. When an object requires calculations of something that involves all records in a data table the amount of required CPU seconds will increase as the amount of records increases. This is all logical that it takes more effors to sum up 100 values than doing the same for 10. To visualize this some benchmarking tests has been performed. By simply monitoring the amount of CPU seconds that has been spent on calculations for some different selections, it is seen how this scales proportional in Figure 25. All measurements have been performed for non-cached selections. The slope of the curve for the different type of selections in the example is not the same however. The reason for this is that a certain selection involves different calculations. Below follows a brief description of what calculations the example selections corresponds to

Sales by Period; Open a sheet that mainly triggers one object with three sum expressions over as many records as there are transactions (i.e. Number of records in Table 2)

Sales by Item; Open a sheet that mainly triggers one object with six calculations of a diverse complexity, all over as many records as there are transactions (i.e. Number of records in Table 2)

Year Selection; Selection at sheet Sales by Item, triggering the same six calculations as triggered when opening the Sales by Item sheet

The Year selection corresponds to selecting slightly more than 1/3 of the original amount of data. When comparing the ratio for the elapsed CPU seconds for the Sales by Item selection and the Year selection this relates proportionally to the amount of selected data (i.e. slightly more than 1/3 CPU seconds needed). This shows that QlikView scales proportionally in its demand for CPU in relation to amount of data.

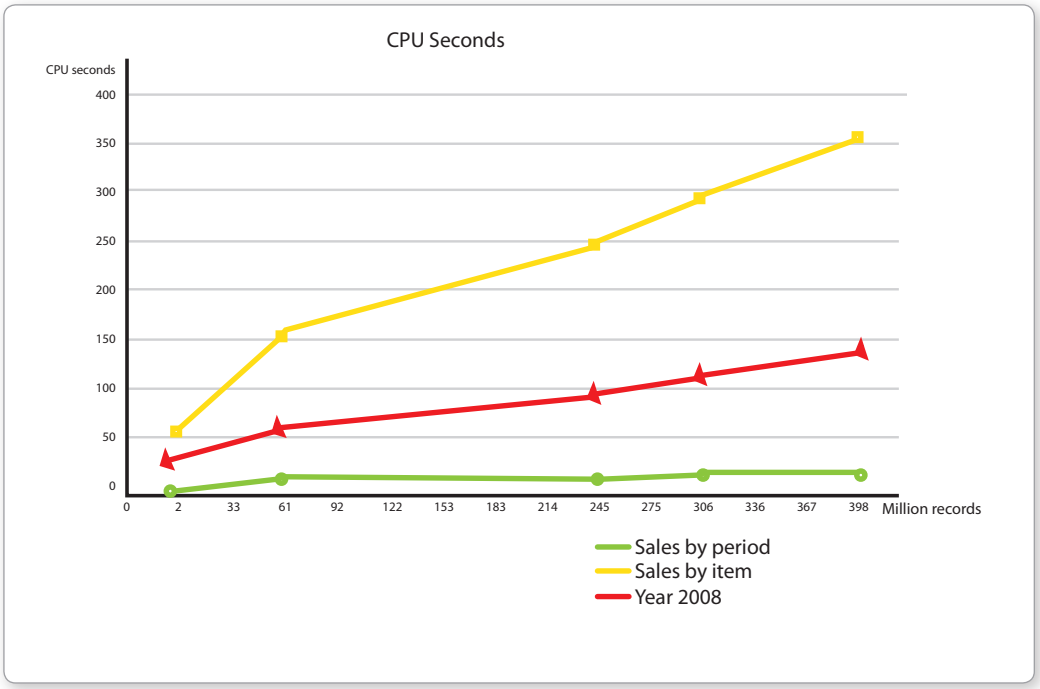


Figure 25: CPU seconds as a function of records

Conclusion – QlikView scales uniformly and predictably and has a proven track record

This paper has outlined how the approach employed by QlikView has been proven to provide consistent and predicable end-user performance when faced with the need to scale up the volume of data needed for analysis or the amount of users required to access the system.

QlikView's product components and architecture allow for horizontal and vertical scaling and are utilized when the demands on the system increase. QlikView scales uniformly, allowing IT professionals to effectively capacity plan for future expected system usage in order to maintain end-user performance at the expected high levels.

QlikView deployments have been consistently proven to be able to handle many thousands of concurrent users and extremely large quantities of data so that end-user performance is high. For IT professionals, system administration follows standard approaches such as clustering, performance monitoring and horizontal and vertical scaling.