A Universal NoSQL Engine, Using a Tried and Tested Technology

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Introduction

You wouldn't expect a programming language from the 1960s to have anything new to teach us, especially one that diverged from the mainstream around the time that Dartmouth BASIC became popular. Even more especially a programming language called MUMPS.

However, surprisingly there is one aspect of this archaic language that is still ahead of it's time. MUMPS has a pearl in its oyster called Global Persistent Variables. These are an abstraction of the B-tree structures that are normally used by MUMPS to store large volumes of data. Global Persistent Variables (usually simply referred to as "Globals") are an expressive and highly efficient way of modelling all of the common use cases that are targeted these days by NoSQL databases.

This paper explains how these Globals can be used to model and store data from each of the distinct types of NoSQL databases: Key/value store, Tabular/Column store, Document store and Graph database, and how, by using the modern, tried and tested MUMPS implementations, you have the best of all worlds: NoSQL capabilities combined with the reliability and maturity needed for business-critical applications.

Note: Globals are not to be confused with the more commonly used term that refers to globally scoped variables. MUMPS Globals are a data storage structure.

For follow-up articles written since this paper was first published, see "The EWD Files": http://robtweed.wordpress.com

A Brief Introduction to NoSQL

The term NoSQL has been around for just a few years and was invented to provide a descriptor for a variety of database technologies that emerged to cater for what is known as "Web-scale" or "Internet-scale" demands.

Put simply, there are three aspects to web-scale:

- big data: the biggest of the web applications out there (*eg* Twitter, Facebook, Google etc) are handling quantities of data that are orders of magnitude greater than anything previously considered for database management

- huge numbers of users: numbered in the millions, accessing systems concurrently and constantly

- complex data: typically these applications aren't handling the simple tabular data that one finds in many commercial and business applications.

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The relational database technologies that have dominated the IT industry since the 1980s began to show their weaknesses in these three areas when pushed to Web-scale, so a growing number of people began looking for alternatives. And so the NoSQL databases began to emerge. Although a variety of models have evolved, they all tend to follow similar patterns:

- they handle the huge quantities of data by breaking it up across servers, a process known as sharding

- they handle the huge numbers of users by spreading the load across servers: ie by using parallel processing

- they use simpler, more flexible schema-free database designs

Without exception, the most successful and well-known of the NoSQL databases have been developed from scratch, all within just the last few years. Strangely, it seems that nobody looked around to see whether there were any existing, successfully-implemented database technologies that could have provided a sound foundation for meeting Web-scale demands. Had they done so, they might have discovered two products, GT.M (http://fisglobal.com/Products/TechnologyPlatforms/GTM/index.htm) and Caché (http://www.intersystems.com) whose persistent data storage is based on Globals. Both products are mature, high-performance products, and highly regarded within their respective user communities. The Global storage engines of both products have bindings from languages and frameworks including Python, Java, .Net and Node.js, making them ideal candidates for NoSQL solutions.

A Quick Overview of Globals

Globals are:

- schema-free
- hierarchically structured
- sparse
- dynamic

Think of a persistent associative array and you're on the right kind of track. Some examples of Globals would be:

```
myTable("101-22-2238","Chicago",2)="Some information"
account("New York", "026002561", 35120218433001)=123456.45
```

Each Global has a name (cf array name). There then follows a number of subscripts whose values can be numeric or text strings. You can have any number of subscripts. Each Global "node" (a node is defined by a Global name and a specific set of subscripts) stores a data value which is a text string (empty strings are allowed).

You can create or destroy global nodes whenever you like. They are entirely dynamic and require no pre-declaration or schema.

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It is up to you, the developer, to design the higher-level abstraction and meaning of a database that is physically stored as a set of Globals. Globals provide no built-in indexing, so to provide the performance needed for searching and querying your data, you must create and maintain additional Global nodes that represent indices.

Globals turn out to be extremely versatile, and can be very easily used to model all four types of NoSQL database with comparable levels of performance:

- key/value stores (eg Redis, memcached)
- tabular, column-orientated databases (eg BigTable, Cassandra, SimpleDB)
- document databases (eg CouchDB, MongoDB)
- graph databases (eg Neo4j)

We'll see later some detailed examples of how this can be done.

Original Design Goals of Global Storage

Globals were originally designed in 1966 to support the management of large volumes of complex and loosely-structured medical and clinical data, and were specifically engineered to be efficient enough to support what was then considered unfeasibly large numbers of concurrent interactive users on the severely limited resources available on PDP mini-computers. Though hardly web-scale, nevertheless Globals were achieving what no other database technologies could achieve at that time, and that tradition has continued to this day: supporting extremely large numbers of users, managing huge volumes of complex data, yet delivering very high performance, on low-cost commodity hardware (*eg* see http://www.redhat.com/pdf/Profile_Benchmark_Results_11_15_2007.pdf and http://www.intersystems.com/cache/whitepapers/Cache_benchmark.html).

In-memory Performance, On-disk Integrity

One of the key reasons for this high performance is the sophisticated caching mechanisms that have been refined and optimised over the years to ensure that, for most of the time, the Global nodes to which you require access are already in memory. Most NoSQL databases still have an immature relationship between in-memory activity (for speed) and on-disk activity (for persistence and integrity) and are open to risk if a node or shard server goes down (*eg* http://highscalability.com/blog/2010/10/15/troubles-with-sharding-what-can-we-learn-from-the-foursquare.html). By comparison, GT.M and Caché have been hardened against such risks. The result is tried and tested in-memory-like performance with on-disk-like integrity, the direct result of decades of real-world experience in demanding environments such as healthcare, finance and banking, where performance, integrity and reliable non-stop operation are essential

Can you spot the similarity with the goals of NoSQL databases?

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Ticking the NoSQL Boxes

Some weeks ago, TechRepublic published a blog named "10 things you should know about NoSQL databases" (http://blogs.techrepublic.com.com/10things/?p=1772). This listed 5 advantages of and 5 challenges for NoSQL databases. In fact, if you judge GT.M and Caché against these 10 criteria, they score a tick against all 5 advantages, but, more interestingly, address 4 out of 5 of the challenges, something no other NoSQL database can boast. Let's quickly look at these criteria:

5 Advantages:

- Elastic Scaling
- Big Data
- Goodbye DBAs
- Economics
- Flexible Data Models

5 Challenges:

- Maturity
- Support
- Analytics and Business Intelligence
- Administration
- Expertise

Taking each advantage in turn:

- **Elastic scaling**: Both GT.M and Caché have, for many years, supported scaling out across multiple servers, and can do so across low-cost commodity hardware. In the case of Caché, their ECP networking technology allows seamless logical views of Globals, where that global can be physically distributed across multiple servers.

- **Big Data**: GT.M and Caché systems are designed to support and manage huge volumes of data, way beyond the limits of relational databases, whilst still delivering extremely high performance.

- **Goodbye DBAs**: interestingly, InterSystems, the vendor of Caché, has used this feature in its marketing for many years. There are stories of Global-based systems that have been running unattended for decades.

- **Economics**: Both GT.M and Caché will happily run on low-cost, commodity hardware and extract maximum levels of performance from them. Partners Healthcare in Massachusetts supported tens of thousands of interactive users throughout the 1980s and 1990s on a networked cluster of hundreds of commodity MSDOS-based PCs running a pre-cursor to Caché.

- **Flexible Data Models**: this is the very essence of Global storage as this paper will later explore.

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As to the challenges:

- **Maturity**: Unlike the new NoSQL databases, GT.M and Caché have a long pedigree and outstanding track record, supporting large complex databases in demanding, real-world business environments. They are robust, extremely reliable and stable technologies that can be confidently used in business-critical situations

- **Support**: GT.M is heavily used in some of the world's largest core banking systems, whilst Caché dominates the healthcare industry. One of the key reasons that they are entrusted to such business- and safety-critical roles has been the quality of the commercial support that is provided by the respective vendors.

- **Analytics and Business Intelligence**: interestingly, InterSystems are now heavily marketing a product called DeepSee, which is designed for exactly this purpose, and is layered on top of their core Global-based database engine. Both GT.M and Caché support connectivity to SQL-based business analytics tools: for many years they have supported both SQL and non-SQL database access

- **Administration**: Both GT.M and Caché are straightforward to install and maintain, and are often used in situations where there are few, if any, skilled IT resources available.

- **Expertise**: This is the one area where GT.M and Caché admittedly fall short. Whilst the user-base for Caché, in particular, has been steadily growing, the number of skilled professionals who have experience in GT.M and Caché is very small compared with the availability of RDBMS skills

Both GT.M and Caché are, in summary, ideal candidates for businesses that require a NoSQL technology but require something that is mature, robust and reliable.

Though both products are commercially licensed and available across a wide variety of hardware and operating systems, GT.M is particularly interesting because it is available as a Free Open Source product when run under GNU/Linux on x86 hardware.

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Modelling the 4 NoSQL Database Types Using Globals

Before we describe how each NoSQL database type can be modelled in Globals, let's first examine the structure of Globals in a little more detail and define some of the terminology that we'll use later.

When storing data in Globals, there are three components that you use to represent a unit of storage:

- Global name.
- subscripts (zero, one or more). These may be text strings or numeric values
- value (the value to be stored). This may be a text string or a numeric value

They are commonly expressed as [n]-ary relational variables in the following form:

```
globalName(subscript1,subscript2,..subscriptn)=value
```

This combination of name, subscripts and value is known as a *Global Node* and is the unit of storage. A Global is a collection of Global Nodes and a database is a collection of Globals.

An important aspect of Globals is that a single named Global can contain nodes with different numbers of subscripts, eg:

```
myGlobal("a")=123
myGlobal("b","c1")="foo"
myGlobal("b","c2")="foo2"
myGlobal("d","e1","f1")="bar1"
myGlobal("d","e1","f2")="bar2"
myGlobal("d","e2","f1")="bar1"
myGlobal("d","e2","f2")="bar2"
myGlobal("d","e2","f3")="bar3"
```

The net result is that a single named Global represents a sparse hierarchical tree of nodes. For example, the Global above effectively represents the following hierarchical tree:

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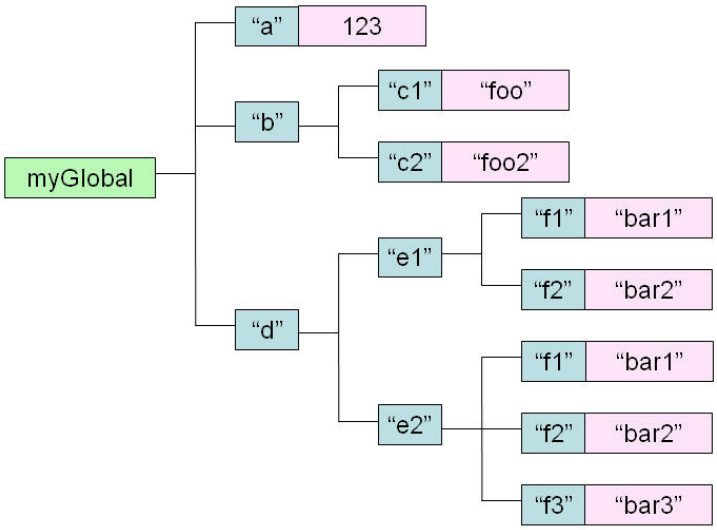

You can create as many different named Globals as you like. So in other words, a database in GT.M or Caché will consist of one or more named Globals, each with its hierarchy of nodes.

There is no explicit relationship between the named Globals in such a database, but there may be implicit relationships that are determined and managed at the application level. There is no explicit schema associated with Globals, and the way in which data is represented within Global nodes is implicitly defined at the application level.

Global nodes are created by using the native command ***set***. All language and framework bindings expose this command. In this paper we'll denote the invocation of the ***set*** command by whatever binding you use as:

Set: `myGlobal("b","c3")="Rob"`

So, for example, if you were using the **node-mdbm** Node.js client (http://github.com/robtweed/node-mdbm), you would create this Global Node as follows:

```
mdbm.set('myGlobal', ['b','c3'], 'Rob', function(error, results) {….});
```

We'll represent the other relevant native commands similarly.

Invoking this command would insert this node to our hierarchy and the tree would now look like the following:

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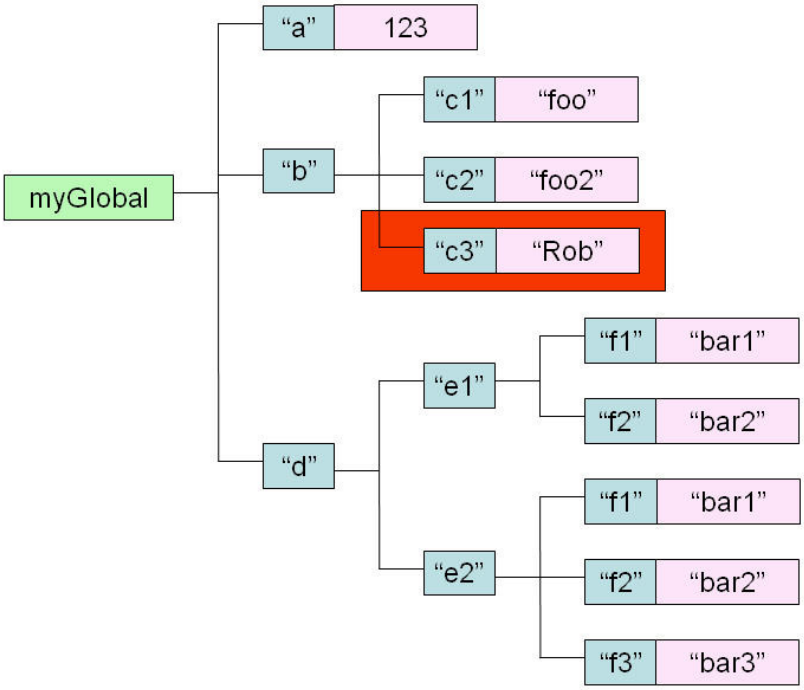

So, with this basic information in mind, now let's look at how you can use Globals for representing the data structures typically found in NoSQL databases.

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1) Key/Value Storage

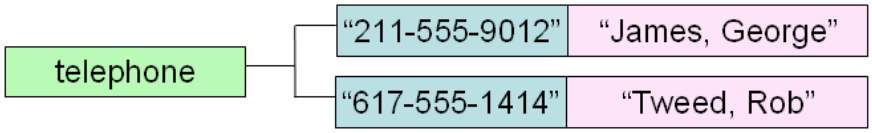
Implementing a key/value store using Globals is simple. You could create a very basic one using the following Global structure:

```
keyValueStore(key)=value
```

eg:

```
telephone("211-555-9012")="James, George"
telephone("617-555-1414")="Tweed, Rob"
```

Viewed as a hierarchical tree:



That's all there is to implementing simple key/values stores, but with Globals you can go further by storing multiple attributes against each key. For example:

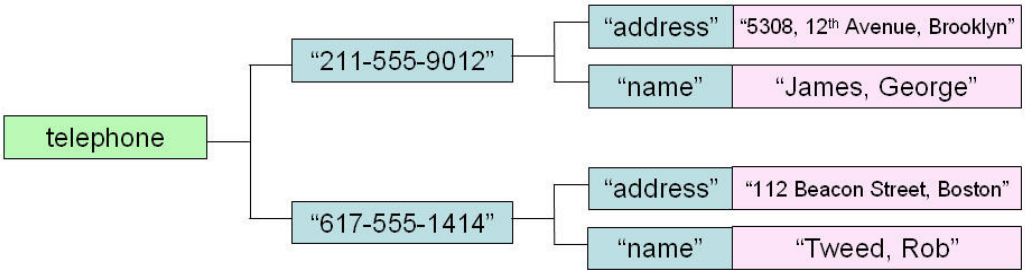
```
telephone(phoneNumber,"name")=value
telephone(phoneNumber,"address")=value
```

eg:

```
telephone("211-555-9012","name")="James, George"
telephone("211-555-9012","address")="5308, 12th Avenue, Brooklyn"

telephone("617-555-1414","name")="Tweed, Rob"
telephone("617-555-1414","address")="112 Beacon Street, Boston"
```

ie we've now created a hierarchical tree that looks like this:



For example, to create the first record in this redesigned key/value store using the **node-mdbm** Node.js client,:

mdbm.set('telephone', [' 617-555-1414','name'], 'Tweed, Rob', function(error, results) {….});

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NoSQL databases typically don't provide automatic methods for indexing data. Neither do Globals. If you want to access data via an alternative key then you simply create a second Global with the alternate item as a key.

For example if you wanted to access the data using name as a key you'd need to add an index Global and update it at the same time as the telephone Global. Designing and adding indices is entirely your responsibility, but is very simple.

Here we add a simple name index by creating the following global nodes every time we add entries to the telephone Global:

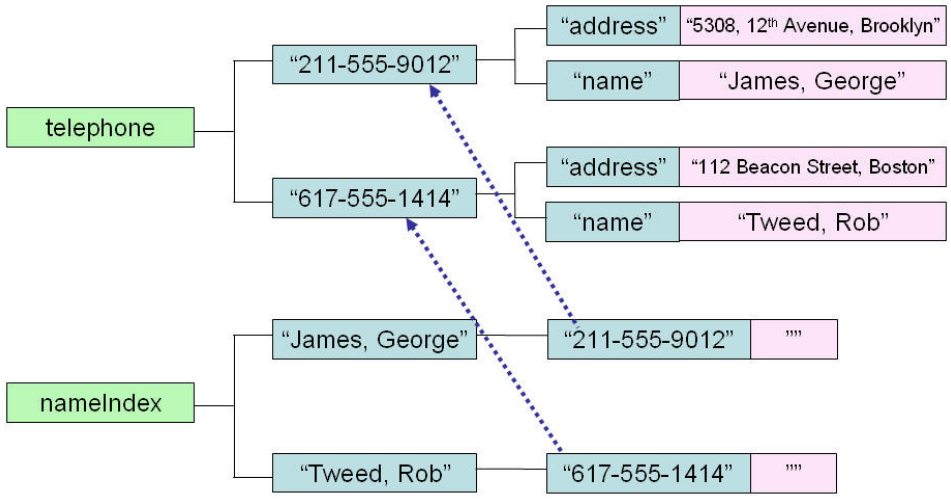
```
nameIndex(name,phoneNumber)=""
```

eg:

```
nameIndex ("James, George", "211-555-9012")=""
nameIndex ("Tweed, Rob", "617-555-1414")=""
```

No data value is necessary for this index, so we just use an empty string.

Viewing the main data Global and our index Global together diagrammatically (the dotted lines show the implied relationships between the index and telephone data nodes):



This index global provides us with a method of accessing our telephone data by name, while the main global allows us to access the data by telephone number.

A very important and powerful feature is that Global Nodes are automatically stored as a sorted set within a Global (as shown in the diagram above). An iterator method is provided that enables the content of every Global to be accessed sequentially. If we wanted to produce a telephone directory from this data we can iterate through the nameIndex Global and then use a get method to access the address data from the telephone Global.

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Natively this iterator is known as the **order** function, and this is exposed in a variety of ways through the various language and framework bindings. For example the **node-mdbm** Node.js client for GT.M provides three commands that are based on **order**:

getNextSubscript
getPreviousSubscript
getAllSubscripts

eg:

```
mdbm.getNextSubscript('nameIndex', ['James, George'], function(error, results) {});
```

would return the next Global Node subscript following 'James, George' in this Global *ie*:

```
{subscriptValue: 'Tweed, Rob'}
```

GT.M and Caché are very highly optimised for traversing subscripts in this way, so if you design your indices well, searching for data in Globals is exceptionally fast.

There are all kinds of ways in which Globals can be designed for use as simple key/value stores. For example, you could redesign our example store using just one single global for both data and indices by adding a further first subscript, eg:

```
telephone("data",phoneNumber,"address")=address
telephone("data",phoneNumber,"name")=name
telephone("nameIndex",name,phoneNumber)=""
```

Since the physical implementation of Globals is abstracted away, you can design the structure of your Globals to precisely match your processing needs. However, if your key/value stores are going to grow to enormous sizes, then you'll need to consider if and how a particular structure will aid or hinder the management of the Global(s) concerned (eg in terms of backup and recovery, maximum database size limits, distribution across multiple shards etc). This kind of consideration can affect whether you store data in one Global or spread it across several Globals.

Other Key/Value Types

If you look at a NoSQL key/value store such as Redis, you'll find that it provides a variety of other types. It turns out that every one of these types can also be very simply implemented using Globals.

Lists

Redis List types are linked lists. You can push values onto a list and pop values off a list, return a range of values, etc.

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To model such a structure using Globals is pretty straightforward. For example you could use a structure such as the following:

```
list(listName,"firstNode")=nodeNo
list(listName,"lastNode")=nodeNo
list(listName,"node",nodeNo,"value")=value
list(listName,"node",nodeNo,"nextNode")=nextNodeNo
list(listName,"node",nodeNo,"previousNode")=prevNodeNo
```

eg a linked list named *myList* that contains the sequence of values:

- Rob
- George
- John

could be represented as:

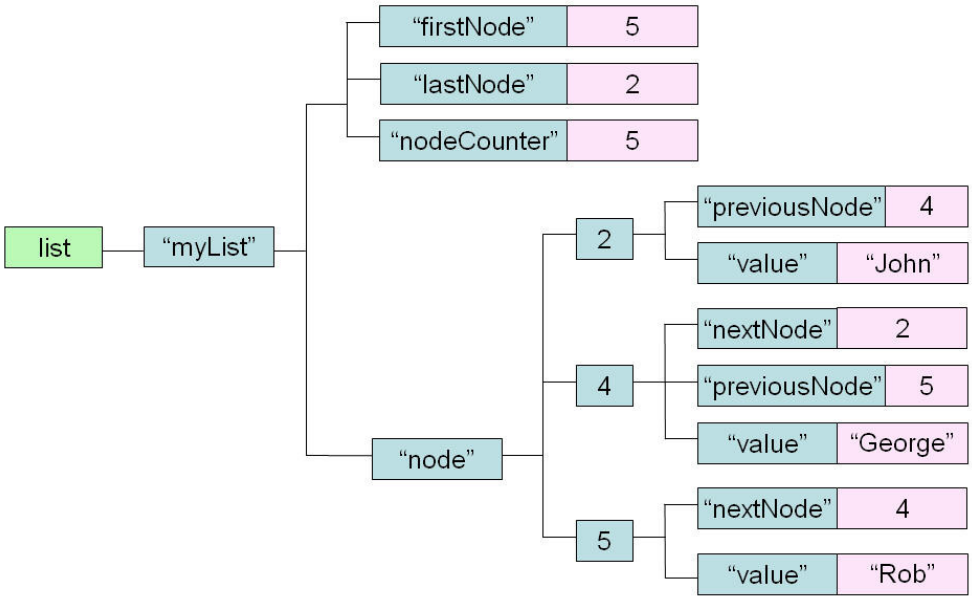
```
list("myList","firstNode")=5
list("myList","lastNode")=2
list("myList","nodeCounter")=5

list("myList","node",2,"previousNode")=4
list("myList","node",2,"value")="John"

list("myList","node",4,"nextNode")=2
list("myList","node",4,"previousNode")=5
list("myList","node",4,"value")="George"

list("myList","node",5,"nextNode")=4
list("myList","node",5,"value")="Rob"
```

or diagrammatically:



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What you see here is the sparse structure of Globals. The node numbers are just sequential integer values. Node 5 is currently the first record in the list, so it has an attribute that indicates the next node, but it doesn't have an attribute to indicate a previous node as there isn't one. The middle node (#4) has attributes for both next and previous nodes.

Each operation that modifies the list, eg pop, push, trim etc, would need to modify a set of nodes within this structure, eg:

- Resetting the first or last node pointer
- Adding or deleting a new node value
- Resetting the relevant next and previous node pointers to add a new node into the list, or to remove a node from the list

So, for example, pushing a new name, "Chris", onto the top of the list would change the list Global as follows:

```
list("myList","firstNode")=6
list("myList","lastNode")=2
list("myList","nodeCounter")=6

list("myList","node",2,"previousNode")=4
list("myList","node",2,"value")="John"

list("myList","node",4,"nextNode")=2
list("myList","node",4,"previousNode")=5
list("myList","node",4,"value")="George"

list("myList","node",5,"nextNode")=4
list("myList","node",5,"previousNode")=6
list("myList","node",5,"value")="Rob"

list("myList","node",6,"nextNode")=5
list("myList","node",6,"value")="Chris"
```

ie diagrammatically (changes to previous hierarchy are highlighted):

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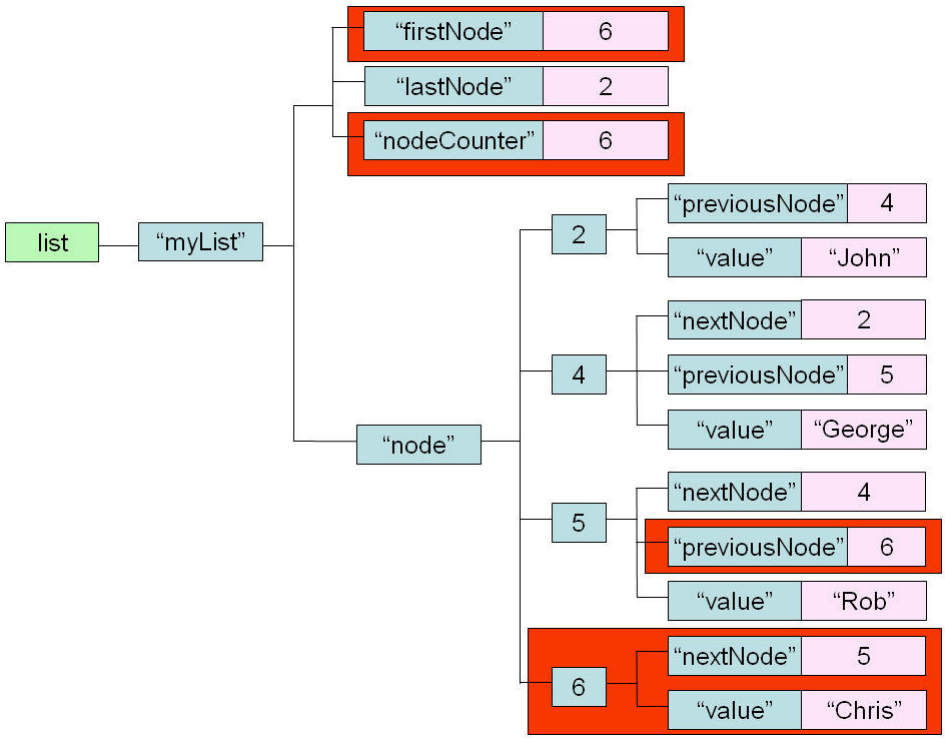
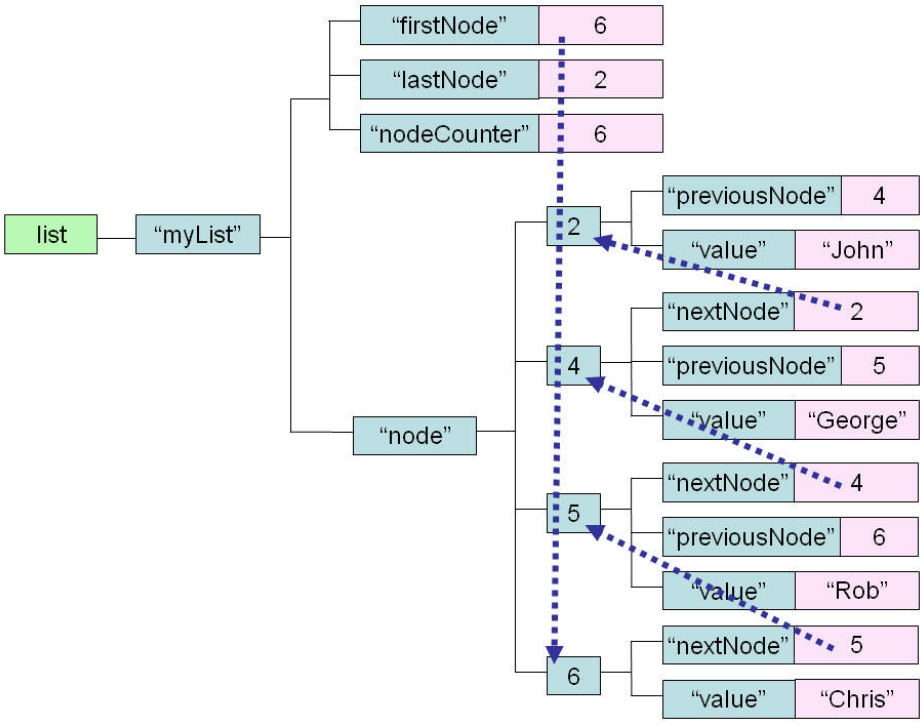


Traversing this list would involve starting at the first node and recursively following the nextNode records until no more are found, ie:



Returning a count of the number of records in the list could be done by traversal of the list, or, for maximum performance, it could be stored as a separate Global node and updated whenever the list is modified, eg:

```
list("myList","count")=noOfNodes
```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Clearly we'd need to implement these operations as methods that manipulate the Global nodes in this model appropriately, but this would be a very simple task.

Sets

Redis Sets are unordered collections of strings. We can easily model something with the same behaviour using Globals:

```
set(setName,elementValue)=""
```

In fact, you'll notice that this is identical to how we defined an index earlier on. So we can add an element to a set:

```
Set: set("mySet","Rob")=""
```

We can remove an element from a set:

```
Kill: set("mySet","Rob")
```

To determine if an element exists or not in a set, we make use of the native **data** command. This will return 1 if the element exists and 0 if it doesn't:

```
Data: set("mySet","Rob") ➔ 1
Data: set("mySet","Robxxx") ➔ 0
```

For example, if you use the node-mdbm Node.js client, you can use the **get** command which will return the **data** value as the property **dataStatus**:

```
mdbm.get('set', ['mySet','Rob'], function(error, results) {});
```

results.dataStatus will be 1

We can use the natural ordering of Global Nodes to list the members of a set in alphanumeric sequence. For example, if you were using **node-mdbm** you could use:

```
mdbm.getAllSubscripts('set', ['mySet'], function(error, results) {});
```

and you'd get back an array of names in alphabetic order, eg

```
["Alan","Brian","Charles","David","Edward"]
```

So, by using Globals, there really isn't any substantial difference between Redis's **sets** and **zsets** when modelled using Globals.

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Hashes

By now you can probably see that hashes can be implemented in exactly the same way as Sets. In fact, Globals are essentially persistence hash tables anyway.

```
hash(hashName,value)=""
```


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2) Tabular (or Columnar) Storage

Table-based or Column-based NoSQL databases such as BigTable, Cassandra and Amazon SimpleDB allow data to be stored as sparse tables, meaning that each row in a table can have a value in some, but not necessarily all, columns. SimpleDB goes further and allows a cell in a column to contain more than one value.

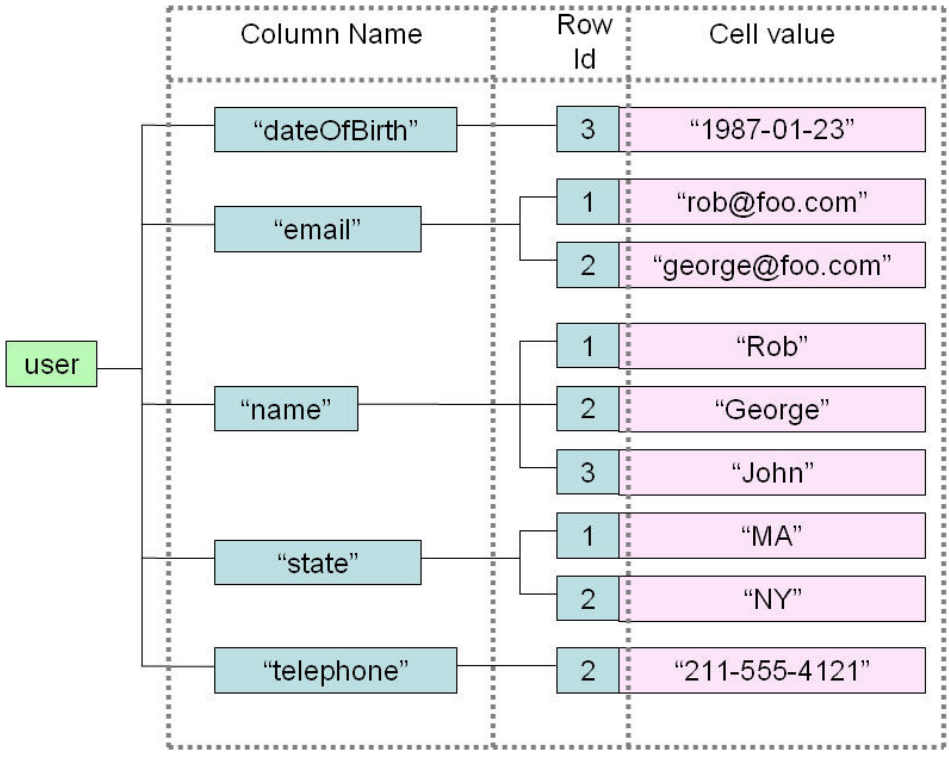
Once again, it turns out that Globals can be used to model such a data store. For example, the following structure would provide the basic features of such a store:

```
columnStore(columnName,rowId)=value
```

eg:

```
user("dateOfBirth",3)="1987-01-23"
user("email",1)="rob@foo.com"
user("email",2)="george@foo.com"
user("name",1)="Rob"
user("name",2)="George"
user("name",3)="John"
user("state",1)="MA"
user("state",2)="NY"
user("telephone",2)="211-555-4121"
```

Or diagrammatically:



Once again, the sparse nature of Globals comes to the fore. The Global above represents the following table:

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	name	telephone	email	dateOfBirth	state
1	Rob		rob@foo.com		MA
2	George	211-555-4121	george@foo.com		NY
3	John			1987-01-23	

We could, of course, add indices to this model, eg by row and by cell value, that would be maintained in parallel with the main column store global, eg:

```
userIndex("byRow",rowId,columnName)=""
userIndex("byValue",value,columnName,rowId)=""
```


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3) "Document" Storage

Document-oriented NoSQL databases such as CouchDB and MongoDB store collections of key/value pairs and recursively collections of collections. Typically, JSON, or JSON-like structures, are used to represent these "documents".

Mapping a JSON document or object to a Global is very straightforward: simply represent names as subscripts and values as the values held at that subscript. For arrays, use a numeric subscript to represent the array position. For example, consider the JSON document:

```
{key:"value"}
```

This can be modelled as:

```
document("key")="value"
```

A more complex document:

```
{this:{looks:{very:"cool"}}}
```

could be represented as:

```
document("this","looks","very")="cool"
```

How about the array:

```
["this","is","cool"]
```

This would be mapped to:

```
document(1)="this"
document(2)="is"
document(3)="cool"
```

Put together a more complex JSON document:

```
{'name':'Rob',
 'age':26,
 'knows':[
    'George',
    'John',
    'Chris'],
 'medications':[
    {'drug':'Zolmitripan','dose':'5mg'},
    {'drug':'Paracetamol','dose':'500mg'}],
 'contact':{
    'eMail':'rob@foo.com',
    'address':{'street':'112 Beacon Street',
               'city':'Boston'},
    'telephone':'617-555-1212',
    'cell':'617-555-1761'},
 'sex':'Male'
}
```


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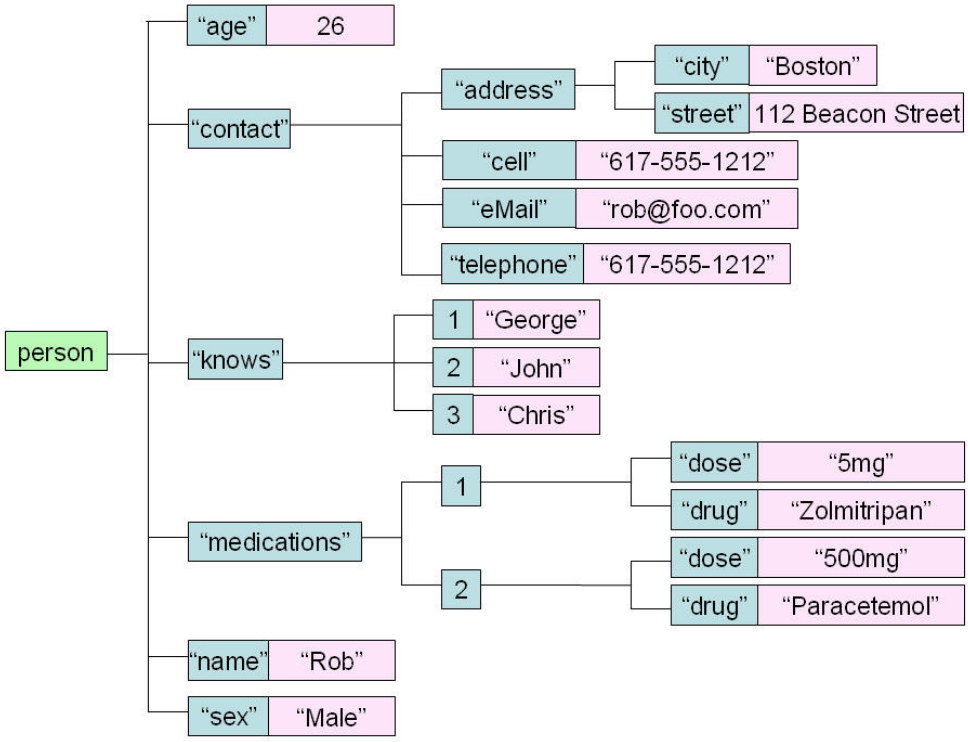
And this would map to:

```
person("age")=26
person("contact","address","city")="Boston"
person("contact","address","street")="112 Beacon Street"
person("contact","cell")="617-555-1761"
person("contact","eMail")="rob@foo.com"
person("contact","telephone")="617-555-1212"
person("knows",1)="George"
person("knows",2)="John"
person("knows",3)="Chris"
person("medications",1,"drug")="Zolmitripan"
person("medications",1,"dose")="5mg"
person("medications",2,"drug")="Paracetamol"
person("medications",2,"dose")="500mg"
person("name")="Rob"
person("sex")="Male"
```

Or diagrammatically:



If you look at the **node-mdbm** Node.js client, you'll find that this is exactly what its ***setJSON*** command will do automatically for you. In fact you can also specify initial subscripts to allow multiple JSON documents to be stored in a single global. eg:

```
documentStore("Rob","name")="Rob"
documentStore("Rob","knows",1)="George"
documentStore("Rob","knows",2)="John"
documentStore("Rob","knows",3)="Chris"
```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In this case, executing the node-mdbm getJSON command:

```
mdbm.getJSON('documentStore', ['Rob'], function(error, results) {});
```

would return just Rob's document:

```
{name:'Rob',knows:['George','John','Chris']}
```


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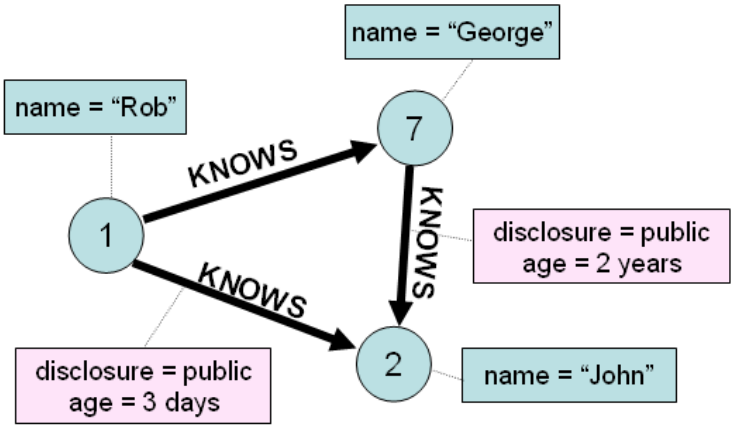
4) Graph Databases

NoSQL graph databases such as Neo4j are used to represent complex networks of relationships in terms of nodes and relationships between nodes (*aka* "edges"), with key/value pairs attached to both nodes and relationships.

The classic use for graph databases is to represent social networks. Take the following example:



This is represented using Globals as:

```
person(personId,"knows",personId)=""
person(personId,"knows",personId,key)=value
person(personId,"name")=name
```

The age of the "knows" relationship would probably be derived from a timestamp key that is created when the relationship is first saved.

eg:

```
person(1,"knows",2)=""
person(1,"knows",2,"disclosure")="public"
person(1,"knows",2,"timestamp")="2008-08-16T12:23:01Z"
person(1,"knows",7)=""
person(1,"name")="Rob"

person(2,"name")="John"

person(7,"knows",2)=""
person(7,"knows",2,"disclosure")="public"
person(7,"knows",2,"timestamp")="2009-12-16T10:06:44Z"
person(7,"name")="George"
```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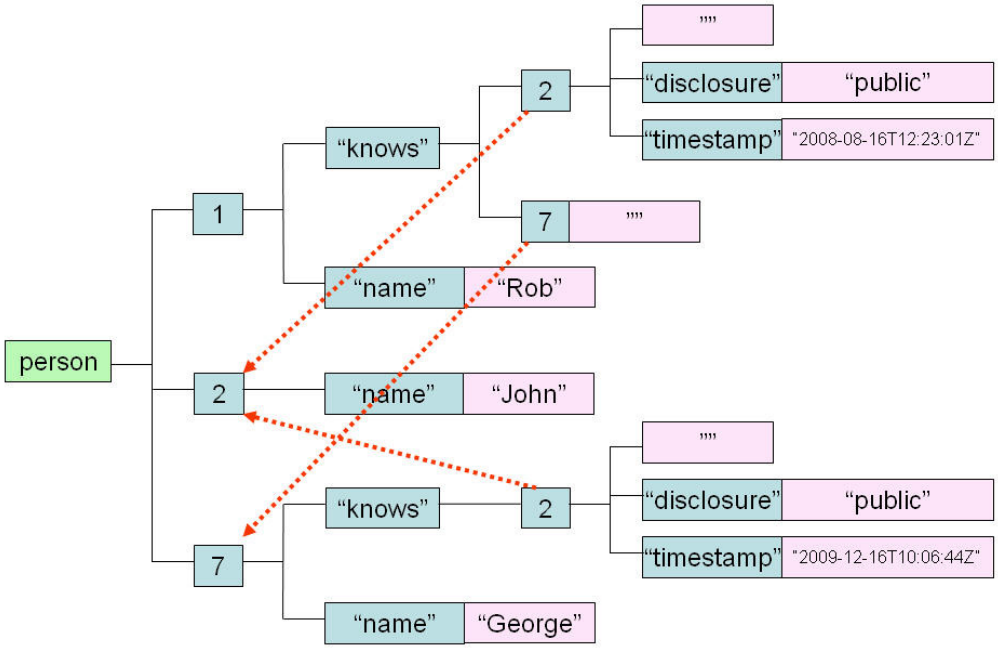
or diagrammatically (the red dotted lines show the implied relationships in this model):



In fact, for a generic graph database, the model would be further abstracted to represent nodes and vertices, for example something like:

```
node(nodeType,nodeId)=""
node(nodeType,nodeId,attribute)=attributeValue

edge(edgeType,fromNodeId,toNodeId)=""
edge(edgeType,fromNodeId,toNodeId,attribute)=attributeValue

edgeReverse(edgeType,toNodeId,fromNodeId)=""
```

So you can see that the flexibility of Globals and their sparse nature lends themselves very naturally to defining complex graph databases.

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5) Other Database Models

Globals aren't just restricted to the NoSQL models. They can also be used to model further database types:

- **XML DOM/ Native XML Database**. If you look at the EWD product (http://www.mgateway.com/ewd.html), you'll find that at its core is an implementation of the XML DOM, modelled into a Global. It is essentially a Graph structure that represents the nodes (and their associated type) and the relationships between them (eg firstChild, lastChild, nextSibling, parent etc). In essence, EWD allows GT.M and Caché system to behave as a Native XML Database

- **Relational tables**. Both GT.M and Caché model relational tables onto Globals (in the case of GT.M they have an add-on product known as PIP, while Caché natively supports relational tables). In both cases it is then possible to use SQL-based queries, both natively within the products and via industry-standard third party tools.

- **Persistent Object Storage**. Caché goes still further and models Objects onto the underlying Global storage, and provides a direct mapping between those objects and relational tables. You can probably now envisage how this might be achieved.

The really interesting thing about both GT.M and Caché is that, unlike the commonly-known NoSQL databases, they aren't shoe-horned into one particular category, and can have multiple, simultaneous characteristics. So a GT.M or Caché system could support any or all of the database types described above, simultaneously if required. So it's like having Redis, CouchDB, SimpleDB, Neo4j, mySQL and a Native XML Database all running in the same database, all at the same time!

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Conclusion

There's more to Globals than just the description we've given. However, hopefully this summary overview has demonstrated that they are a nice means of abstraction that is flexible and makes modelling many different use cases very easy. The secret sauce, of course, is their implementation. If done correctly, there are smart design choices that really make for astounding performance. We'll describe more about that in a future article.

Since this paper was published, Rob has written extensively around the topics covered above. See his blog: "The EWD Files": http://robtweed.wordpress.com

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