# Scale-Out with MySQL Cluster Carrier Grade Edition and AdvancedTCA®

## An introduction to the benefits of enabling Scale-Out with MySQL Cluster Carrier Grade Edition and AdvancedTCA

**A MySQL® Business White Paper**

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# Introduction

In the wake of the latest wave of large industry consolidations within the telecommunications industry, Alcatel-Lucent, Nokia Siemens Networks to name a few, the competition for delivering next-generation IP-based communications infrastructure that power services to consumers is only intensifying. These services range from various messaging, presence, gaming and other on-demand multimedia services for cell phones and other wireless devices. This ever increasing demand for new services, coupled with the convergence of traditional networks onto ones that are IP-based, are pushing Telecom Equipment Manufacturers (TEMs) and Network Service Providers (NSPs) to adopt more streamlined and adaptable business models. This is required in order to stave off competition, integrate new technology innovations at a faster pace and nimbly respond to the demands of an ever changing marketplace.

At the same time, forward thinking TEMs and Network Service Providers NSPs are migrating from proprietary, often in-house developed hardware and software to open, standards-based components to improve product capacity, reduce costs and deploy applications faster. The Advanced Telecom Computing Architecture hardware standard, also known as AdvancedTCA® is the telecom industry's first specification for carrier-grade equipment which enables the integration of highly available computing power and switched fabric networking components. In this paper we explore how the leading open-source, shared-nothing cluster database, MySQL Cluster Carrier Grade Edition is well positioned to take advantage of this open, multi-vendor standard. By leveraging the advancements in networking and processing power which AdvancedTCA delivers in a tightly integrated and cost saving form factor, it allows telecom companies to enable scale-out, realize lower total cost of ownership and an even higher return on investment when building subscriber-centric applications and networks.

# AdvancedTCA Overview

AdvancedTCA has become the largest specification effort in the history of the PCI Industrial Computer Manufacturers Group (PICMG). The AdvancedTCA specifications were designed through the participation of a large ecosystem of over 100 companies including: Intel, Motorola, Alcatel-Lucent, Nokia-Siemens and HP. As a result, AdvancedTCA continues to gain wide acceptance from small and large companies alike, as no one single entity holds a monopoly on the design specifications.

The intention of AdvancedTCA is to address the requirements of the next generation of carrier grade communications equipment and applications. This specification encompasses the recent advancements in interconnect technologies, processors, and improvements reliability and availability.

## Business Advantages of AdvancedTCA

AdvancedTCA enables the telecommunications industry to adopt a standard architecture for a broad spectrum of products including wireless access, wireless core networks, and IP Multimedia Subsystem (IMS) network elements. Using existing industry standard COTS (Commercial of the Shelf) software and hardware components provides organizations with a number of benefits including:

- **Lower Development Costs –**TEMs used to develop their own proprietary systems including the operating system, database and the underlying hardware. However, AdvancedTCA allows TEMs and NSP to purchase COTS hardware such as chassis, computing blades, storage, and switch blades saving them the development costs of each of these components. This move has been referred to as a "make specific" to "buy standard" evolution and it enables all telecommunications vendors to leverage the engineering effort of a single AdvancedTCA hardware vendor. In turn, adopting AdvancedTCA allows the TEM and NSP to focus on the value add software and services that are core to their business. Motorola estimates that the cost savings between a

customer producing in-house boards, communications servers and a high availability environment can be over $33 Million dollars.[1]

- **Reduced OPEX –** In addition to lowering development costs, TEMs and NSP can also reduce operational costs. Proprietary software and hardware stacks are not only expensive to develop, but they require specialized development and administration skills to maintain. Also, older proprietary equipment becomes difficult and sometimes impossible to replace in case of failure. By using a common and standard infrastructure, TEMs and NSPs can reduce the maintenance costs as well reduce spare inventory and repair costs.
- **Faster Time to Market –** Delivering new services quickly is critical for NSPs to increase the ARPU (Average Revenue per User) and ultimately their success. However, a vertical solution approach where by the TEM develops the entire software and hardware stack is too rigid and requires too much manual intervention. This makes it cumbersome and time consuming to deliver new services. Using interoperable COTS components like Carrier Grade Linux, AdvancedTCA hardware and MySQL Cluster Carrier Grade Edition gives TEMs and NSPs greater flexibility and a competitive edge to get products and services faster.
- **Investment Protection –** Implementing standards based COTS components protects organizations from proprietary vendor lock-in. Proprietary software and hardware stacks typically require a huge up-front investment and exposes the TEM or NSP to potentially higher switching costs in the event the necessary SLAs or new services can't be delivered fast enough.

## Technical Advantages of AdvancedTCA

Several key advantages of AdvancedTCA include the reduction of space requirements for components, improvements in performance and power consumption. These are all factors which go into a business realizing a substantial return on investment by moving to a standardized architecture like AdvancedTCA.

Some of the improvements made possible by AdvancedTCA over previous specifications like CompactPCI include:

- Support for two power modules and two power rails to each slot provide hardware redundancy. The obvious advantage here is that it allows for the mitigation of a possible single point of failure. This includes a distributed 48V power system.
- AdvancedTCA supports carrier-grade standards and features such as NEBS, UL, CSA, EU, etc. which are designed to help assure that the equipment is easy to install, operates reliably, and efficiently occupies space. This helps to reduce product installation, maintenance costs and increase the availability of the system.
- A high-capacity packet-based backplane which supports up to 2.5 Tb/s. When combined with lower latency times, this enables AdvancedTCA systems to process a distributed workload much faster.
- With a highly scalable, switched fabric architecture which was originally based on Gigabit Ethernet and in subsequent versions of the standard now offering specifications for InfiniBand, StarFabric, and PCI Express interconnects. A key benefit here is that it helps systems bypass the I/O bottlenecks that were experienced by conventional bus-based architectures.
- AdvancedTCA offers built-in support for up to 200 watts per board and as many as 16 boards per shelf. This significantly increases performance density, allowing each blade to have two or more high-end processors through design improvements in cooling and heat dissipation.

The official specification designation for AdvancedTCA is PICMG 3.0 through PICMG 3.4. An overview of these specifications is detailed below in Figure 1.

[1] Motorola, Inc. http://www.motorola.com/computing/sourcingbenefits

| Specification Number | Specification Description |
|---|---|
| PICMG 3.0 | Core specification defining architecture mechanicals, power, system management, fabric connectors, and Base interface (10/100/1000 Base-T) |
| PICMG 3.1 | Specification for Ethernet and Fibre Channel Fabric interface |
| PICMG 3.2 | Specification for InfiniBand Fabric interface |
| PICMG 3.3 | Specification for StarFabric/Advanced Switching interface |
| PICMG 3.4 | Specification for PCI Express and Advanced Switching Fabric interface |

*Figure 1: PICMG Specifications*

Prior to the adoption of AdvancedTCA, telecom equipment manufacturers were forced to acquire or develop internal proprietary hardware and software to meet the very high service-level demands of their end-users. Because AdvancedTCA is an architecture that supports the interoperability of multiple components, this gives the equipment manufacturer a wider array of choices in the types of hardware and applications they can mix and match. This freedom which AdvancedTCA fosters lowers associated purchasing costs, promotes interoperability, and eliminates vendor lock-in, thereby lowering the total cost of ownership and maximizing the return on investment.

As more new services are added to networks, carriers are being forced to deliver higher-capacities on their networks, despite the fact that the costs for deploying and maintaining these networks continues to rise. This trend has also encouraged the adoption of AdvancedTCA. Intel has predicted the worldwide revenue for AdvancedTCA would reach $7.9 billion in 2009.[2]

# MySQL Cluster Carrier Grade Edition Overview

MySQL Cluster is an open source database technology developed by MySQL AB that brings high availability, scalability and performance to database applications. MySQL Cluster uses standard MySQL Server technology with a clustered storage engine called NDB. MySQL Cluster can be accessed using any of the various MySQL connectors like PHP, Java or .Net, which provide access to the full LAMP stack. Data can also be accessed and manipulated directly using MySQL Cluster's native NDB API. This C++ interface provides fast, low-level connectivity to data stored in a MySQL Cluster. A Java version of NDB API is also available, called NDBJ.

MySQL Cluster Carrier Grade Edition is a version of MySQL Cluster specifically designed to better serve the business and technical challenges currently facing TEMs and NSPs with the next-generation of services and applications for converged networks. MySQL Cluster Carrier Grade Edition is developed in close cooperation with some of the largest TEMs in the industry. This is being done to ensure their real-world high availability, scalability, and performance requirements to run the most demanding telecom applications are met. MySQL Cluster Carrier Grade Edition is a shared-nothing clustered database with a fault tolerant architecture and no single point of failure. In essence, MySQL Cluster Carrier Grade Edition delivers mainframe reliability on AdvancedTCA hardware. This makes it the most cost-effective solution for database high availability and scalability.

## Designed by Telecom for Telecom

MySQL Cluster Carrier Grade Edition began as a technology acquired from an Ericsson spin off called Alzato in 2003. The purpose was to provide a high availability data management system designed

[2] RTC Magazine: http://www.rtcmagazine.com/home/article.php?id=100490

specifically for telecom applications and IP network environments. In 2004, MySQL announced the general availability of MySQL Cluster 4.1 and version 5.0 in 2005. In February 2007, MySQL announced an additional offering called “MySQL Cluster Carrier Grade Edition”.

MySQL Cluster is the preferred high availability solution for applications like Web session management, payment validation, online gaming, front-end caching, and “look to book” databases. For TEMs and NSPs developing network services with extreme requirements on the underlying database, we recommend MySQL Cluster Carrier Grade Edition. These telecom requirements include 99.999% availability, scalability in terms of 10s of thousands of transactions per second and millisecond response times. In addition to these requirements, telecom databases should be easy to integrate into legacy systems and run on low-cost commodity off-the shelf and AdvancedTCA hardware. These are all core characteristics of MySQL Cluster Carrier Grade Edition.

MySQL Cluster Carrier Grade Edition is being widely deployed by TEMs and NSPs on AdvancedTCA hardware for GSM (Global System for Mobile communication) and IMS (IP Multimedia Subsystem) products, including:

- HSS (Home Subscriber Systems)
- HLR (Home Locator Registry)
- AAA (Authentication, Authorization and Accounting)
- WAS (Wireless Access Servers)

You will also find MySQL Cluster Carrier Grade Edition leveraged as a component in other types of telecom products, like:

- VoIP (Voice Over Internet Protocol) Systems
- Application Servers for IMS
- Softswitches
- Intelligent Networks
- Value Added Services
- Online Charging
- Identity Management
- Presence Management

MySQL Cluster Carrier Grade Edition is the proven solution deployed on systems today handling millions of subscribers, providing unrivalled performance and quality of service, while meeting the need for increasing demands on scalability as new services and networks extend globally. MySQL Cluster Carrier Grade Edition was introduced to meet these unique technical and business challenges.

## MySQL Cluster Carrier Grade Edition components and architecture

MySQL Cluster Carrier Grade Edition consists of three different types of nodes, each providing specialized services within the cluster.

**Data Nodes** are the main nodes of the cluster. They provide the following functionality to the cluster:

- Data storage and management both in-memory and on disk
- Automatic and user defined partitioning of data
- Synchronous replication of data between data nodes
- Transactions and data retrieval
- Fail over
- Resynchronization after failure

By storing and distributing data in a shared-nothing architecture, i.e. without the use of a shared-disk, if a data node happens to fail, there will always be at least one additional Data Node storing the same

information. This allows for requests and transactions to continue to be satisfied without interruption. Moreover, it is possible to choose how to store data; either the data can be stored on disk or in-memory. In-memory storage can be used on data that is frequently changing (the active working set). Data stored in-memory is check pointed to disk and can be recovered in case of a system failure. Disk-based data can be used to store data with less strict performance requirements, where the data set is bigger than the available RAM. As in most other RDBMSs, a page-cache is used to increase performance on disk data, by caching frequently used data.

**Application Nodes** are the applications connecting to the database. This can take the form of an application leveraging the high performance APIs, such as the NDB API and NDB/J or the use of MySQL Servers which perform the function of SQL interfaces into the data stored within a cluster. A common approach is to access the data from the real time applications using the NDB API, and do operations and maintenance using the SQL interface where real time performance is not an issue.

Data Nodes do not require any specific Application Nodes to be available and running in order to service requests from other Application Nodes, meaning that there is interdependence between Application Nodes. In this way, by minimizing the interdependency of nodes, the cluster is able to minimize any single points of failure.

**Management Nodes** manage and make available to other nodes cluster configuration information. The Management Nodes are used at startup, when a node wants to join the cluster, and when there is a system reconfiguration. Management Nodes can be stopped and restarted without affecting the ongoing execution of the Data and Application Nodes. By default, the Management Node also provides arbitration services, in the event there is a network failure which leads to a “split-brain” or a cluster exhibiting “network-partitioning”.

With this distributed architecture, where dependencies have been minimized, applications continue to run and data remain consistent, even if any one of the data, application, or management nodes fail. Below in Figure 2 we have illustrated a high-level diagram of the cluster’s architecture in the context of the nodes residing on various blades of an AdvancedTCA chassis.

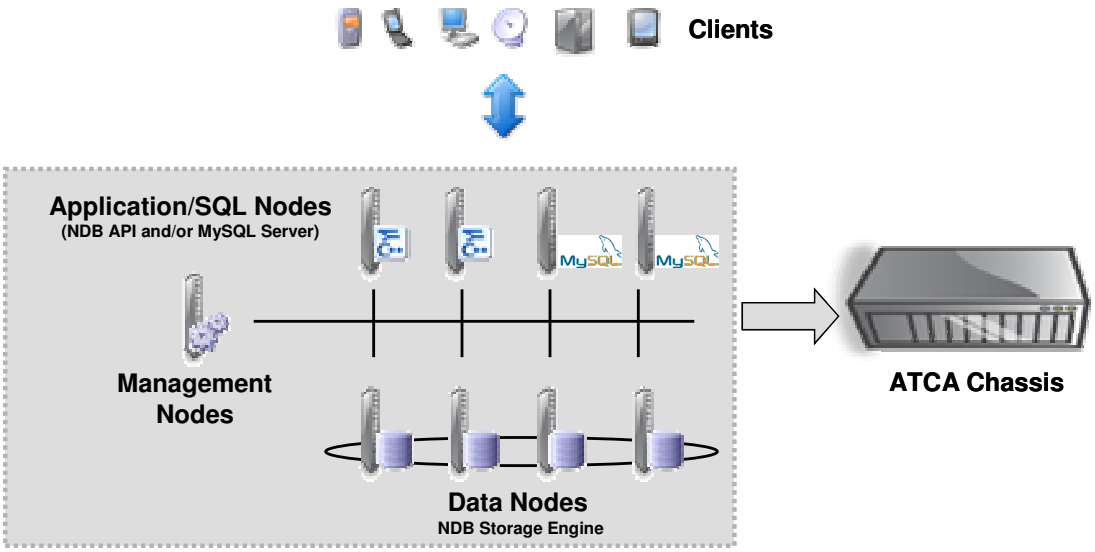



*Figure 2: MySQL Cluster Architecture*

# Advantages of MySQL Cluster Carrier Grade Edition

Using MySQL Cluster Carrier Grade Edition as the database component within an AdvancedTCA technology stack addresses many of the requirements found in today's most demanding telecom applications. Below, in Figure 3 is a listing of the relevant feature sets found in MySQL Cluster Carrier Grade Edition and how they relate to some the standard requirements of carrier grade databases.

| Requirement | MySQL Cluster Carrier Grade Edition |
|---|---|
| **High Availability** | • Distributed, "shared-nothing" data storage<br>• Automated fail over in under a second<br>• Automatic data resynchronization in the event of a failure<br>• Online backups<br>• Rolling upgrades |
| **Performance** | • Hybrid in-memory and disk-based storage<br>• Fast, native data access via NDB API |
| **Scalability** | • Incrementally "scale-out" for increased capacity, performance and availability<br>• Linear scalability with user-defined partitioning<br>• Support for disk-based data and large objects |
| **Geographic Replication** | • Increase availability/scalability across geographies and data centers<br>• Mitigate potential network or site failures<br>• Enables Scale-out<br>• Asynchronous data replication |
| **Reliability** | • Support for ACID transactions<br>• Synchronous intra-cluster data replication<br>• Local and Global checkpoints to disk for durability<br>• 24x7 Technical Support<br>• Professional training and certification |
| **Interoperability** | • Most popular open source database in the world<br>• Runs on popular open source *and* proprietary hardware and software stacks<br>• Compatible with database-independent APIs or existing relational subscriber models |
| **Rapid Development** | • SQL, Java and NDB API data access<br>• Automated and user-defined data partitioning<br>• Professional consulting and customized application development from MySQL<br>• Leverage telecom specific features |
| **Lower TCO** | • Runs on commodity, ATCA hardware<br>• Lower cost licensing model<br>• Minimized design complexity and associated maintenance costs<br>• Based on open source and open standards |

*Figure 3: Requirements for Telecom databases*

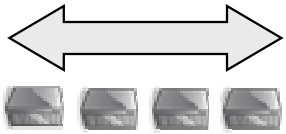
# Benefits of AdvancedTCA with MySQL Cluster CGE

## Scale Out vs Scale Up with AdvancedTCA

One of the most important advantages that can be exploited when designing and deploying telecom applications with MySQL Cluster Carrier Grade Edition and AdvancedTCA is the ability to "scale-out" incrementally to gain the desired level of performance and capacity a fraction of the cost of employing a "scale-up" approach. Data Nodes can be added to increase capcacity and reliability, while Application Nodes can be added to allow for more scalability in performance.

- ***Scale-Up***
  - Vertical
  - Expensive SMP hardware
  - Proprietary software
  - Platform lock-in
  - "Fork Lift" to increase capacity & performance

- ***Scale-Out***
  - Horizontal
  - AdvancedTCA hardware
  - Open standards
  - Open source software
  - Platform independence
  - Add blades to increase capacity & performance



A database typically has two types of scalability requirements; first the amount of data the database can physically store, and second is the number of transactions that can be processed by the database. Each Data Node of a MySQL Cluster stores a partition of the database, and additional data can be stored by scaling out with more blades, i.e. more memory and disk to store more partitions. The number of CPUs determines the amount of transactions that can be processed by the cluster. Therefore, by adding blades to a cluster, one is effectively add more CPUs and therefore more processing power. The m+n scalability model of MySQL Cluster Carrier Grade Edition works very well within the AdvancedTCA environment.

> *"With MySQL Cluster Carrier Grade Edition, we have successfully migrated to an ATCA-based Linux platform. This has allowed us to standardize our platform to take advantage of an open IT blade solution and at the same time, keep the high levels of scalability and availability required by our customers, including Tier 1."*
>
> **Hervé Saliou**
> **Business Manager, Subscriber Database Management BU**
> **Alcatel-Lucent**

## Leveraging AdvancedTCA's high backplane capacity

Because MySQL Cluster has a clustered, shared-nothing storage backend, the high speed intra-node communication that AdvancedTCA supports is an important consideration when designing highly scalable clusters. The right choice of interconnect and networking technology will likely yield significant performance gains. Leveraging the up to 2.5 Tb/s that AdvancedTCA supports one can:

- Improve the latency of the cluster's node intercommunication
- Increase the likelihood of sustained linear scalability regardless of the number of nodes
- Improve the speed of recovery and fail-over operations

One of MySQL's certified partners, Dolphin Interconnect Solutions, supplies products for AdvancedTCA as part of the Dolphin Express product line. It provides full compatibility through Dolphin SuperSockets for applications using sockets communication with TCP, UDP or RDS. Dolphin Express is a complete interconnect architecture combining process-to-process, storage and I/O expansion connectivity. For more information concerning the performance characteristics of Dolphin Express and MySQL Cluster Carrier Grade Edition, please see:

http://www.mysql.com/why-mysql/benchmarks/CGE-Intel-Dolphin.html

A final advantage of AdvancedTCA in this area is that it allows for flexibility in mixing and matching the appropriate blades and backplanes from different, but compatible vendors.

## Exploiting AdvancedTCA performance density

With the multiple-CPUs and cores available on AdvancedTCA hardware, it opens up the possibility to run multiple processes, whether they are Data Nodes or Application Nodes on a single blade. For example, one could run multiple MySQL Servers on a multi-cpu/core system for a denser profile in generating more load against the cluster. There are also some additional features which are perfect for these types of boards as well. The source code for these features is currently available and will be incorporated into subsequent versions of MySQL Custer Carrier Grade Edition this year. They include:

- Setting threads to real-time priority
- Locking threads to a CPU

## Built-in redundancy and high availability features

MySQL Cluster Carrier Grade Edition is designed with high-availability features built-in to mask the complexity of failure detection, Data Node fail-over and recovery operations. This is akin to the availability philosophy behind AdvancedTCA with redundant power supplies and other high availability components inherent to the design specifications.

## Elimination of costly shared storage

MySQL Cluster's storage can be characterized as a shared-nothing clustered architecture, which means that it scales on multiple blades who do not share any memory or storage. These would be standalone blades running their own copy of the operating system, who communicate via the backplane. The nodes running on each blade will also typically store their data on local disks. Therefore, no additional storage appliance (e.g. a SAN) is needed in order to store the clustered data. External storage boxes bring additional complexity to the configuration and manage the database platform. A storage appliance also adds to the hardware cost of the solution, and that cost may be prohibitive when shipping test/trial systems with a few thousand users.

## Achieving high performance even with under performing disks

Databases are typically disk intensive, and generally require plenty of bandwidth and low latency access to data residing on disk. Admittedly, today's AdvancedTCA systems may not always have the fastest or largest internal disks, but because MySQL Cluster Carrier Grade Edition can store database tables in-memory access to the database will not incur any I/O penalty. The administrator is able to configure the interval in which the database and transaction checkpoints occur. In controlling these checkpoints it permits the administrator to maintain the load on the disk to a more even and constant data transfer rate. This allows for, performance of the database to become CPU bound rather than being I/O bound.

### Ability to run diskless

Equipment providers can also take advantage of the ability to leverage Data Nodes on diskless blades in order to scale out throughput. Understanding that of all the hardware components in an AdvancedTCA chassis, disk drives are the component most likely to fail. In order to eliminate this predicament, some providers use diskless configurations to increase simplicity and reliability. Another advantage to removing disk drives from a configuration also results in faster system boot times. It is also possible to run MySQL Cluster Carrier Grade Edition entirely in RAM, without having any disk checkpoints by the data nodes. Data may still be made persisted by a combination of online backups and by enabling the Cluster's replication binary log (which is similar to a transaction log on other RDBMs) generated by a MySQL Server process.

### Based on Open Standards

As previously mentioned, MySQL Cluster Carrier Grade Edition can be leveraged via standard connectivity interfaces like SQL, JDBC, and ODBC. MySQL Cluster Carrier Grade Edition is open source, runs on many popular Linux distributions, as well as, proprietary Unix variants. This allows for cost-effectively meeting the real-time data management requirements of the converged network with minimal interoperability or migration hassles. Because MySQL Cluster Carrier Grade Edition is a standards-based, relational database, that uniquely lends itself to AdvancedTCA's architecture, it makes deploying telecom applications far more cost effective than proprietary databases.

## Case Study: Alcatel-Lucent

As a leader in fixed, mobile and converged broadband networking, IP technologies, applications and services, Alcatel-Lucent offers end-to-end solutions that enable service providers, enterprises and governments worldwide, to deliver voice, data and video communication services to end-users. Alcatel-Lucent is also one of the world leaders in ATCA deployments, with many of their products having made the switch to AdvancedTCA.

Up until 2005, Alcatel's legacy HLR system had been based on proprietary database technology. However given the enormous growth in the number of subscribers the system was to manage effectively, it became apparent to Alcatel that they needed a new solution. In addition to being a viable alternative in the long run, the subscriber database at the heart of the application needed to provide more flexibility and to deliver higher performance, scalability, and reliability at a lower cost. After an extensive evaluation period and numerous performance benchmark tests, Alcatel selected MySQL Cluster Carrier Grade Edition as their database of choice for their next generation HLR solution.

The next step was to select the databases they wanted to evaluate, to determine how well each of them matched the defined requirements, and to run specific benchmarks simulating "real life" conditions to test their performance. "Performance is absolutely critical" said Alain Chastagner, Systems Manager at Alcatel-Lucent, "the selected database would need to initially handle the information of 7 to 8 million subscribers and to subsequently scale to handle more than 50 million subscribers! MySQL Cluster won the performance tests hands down" continues Alain Chastagner "and it fitted our needs perfectly. The combination of accessing the data in memory and backing it up on disk makes MySQL Cluster an ideal solution for our subscriber database platform. Moreover, competing alternatives offered inferior performance at a higher cost."

Alcatel consequently selected MySQL Cluster Carrier Grade Edition for its subscriber database platform to be used by the following applications:

- HLR/AuC: managing the subscriber's data, including real time localization , as well as the authentication and encryption functions on the 3GPP networks (GSM/GPRS/UMTS)
- IM-HSS: managing subscriber's information on IMS (IP Multimedia Subsystem) Networks

- UMA: for subscribers on UMA (Unlicensed Mobile Access) networks connecting via Bluetooth and Wi-Fi access points
- AAA (Authentication, Authorization and Accounting): Access control application for the UMA network and WiMAX

MySQL Cluster Carrier Grade Edition runs on a ATCA compliant hardware platform. Within this platform, different MySQL Cluster processes run on 3 types of processor boards:

- Control boards for OAM operation and the application database management layer
- “Real time” boards for the application itself, and the MySQL NDB client
- “Database” boards for the MySQL NDB Data Nodes, with the whole cluster distributed over all these boards

All boards are interconnected via an Ethernet backplane. External interfaces are connected through the LAN either on the control boards, using the OAM protocol, or the “real time” boards. The next generation subscriber database platform based on MySQL Cluster Carrier Grade Edition and ATCA hardware enabled Alcatel customers to reduce their cost per subscriber, and therefore to increase margins while improving their competitiveness. A number of evolutions are already planned for the platform including moving to 64 bit hardware, and upgraded ATCA systems. In addition, thanks to the flexibility of MySQL Cluster Carrier Grade Edition, Alcatel is planning to implement a multi-cluster architecture for the subscriber database that will scale to handle the information and requests of well over 60 million subscribers! MySQL delivers the real-time performance required by Alcatel’s distributed converged network.

On June 13, 2007 it was announced that Alcatel-Lucent's XDMS product, which is at the heart of the IMS (IP Multimedia Subsystem) infrastructure and related communication services, had been successfully implemented using MySQL Cluster Carrier Grade Edtion. This system provides the configuration and management of contacts, profiles and user groups, as well as presence access authorizations. The data must be accessible via HTTP from any service, any access point and any device. The XDMS system is an XML database designed to support millions of users, generating a high level of traffic. The XDMS system can be deployed on both AdvancedTCA and Rack Mounted Server architectures.

# Conclusion

With the rapid adoption of the telecom industry’s first specification for carrier-grade equipment which enables the integration highly available computing power and switched fabric networking components, AdvancedTCA is revolutionizing the way TEMs and NSPs are designing and deploying their next-generation of services and applications. Because MySQL Cluster Carrier Grade edition can take full advantage of this open, multi-vendor standard it allows telecom companies to enable scale-out, realize a lower total cost of ownership and an even higher return on investment when building subscriber-centric applications and networks.

# Additional Resources

Official AdvancedTCA website
http://www.picmg.org/v2internal/newinitiative.htm

### *White Papers*

Building Subscriber Databases Using MySQL Cluster Carrier Grade Edition
http://www.mysql.com/why-mysql/white-papers/mysql_wp_subscriber_db.php

MySQL Cluster Carrier Grade Edition Business White Paper
http://www.mysql.com/why-mysql/white-papers/mysql_wp_cluster_cge_business.php

MySQL Cluster Architecture Overview
http://www.mysql.com/why-mysql/white-papers/cluster-technical.php

### *Customers: Case Studies and News Articles*

Alcatel-Lucent and MySQL Cluster Carrier Grade Edition Case Study
http://www.mysql.fr/why-mysql/case-studies/mysql_cs_alcatel.pdf

Nokia & MySQL Collaborate on Next Generation Telecommunications
http://www.mysql.com/news-and-events/press-release/release_2006_11.html

Alcatel Selects MySQL Cluster for its Next-Generation Telecom Network Products
http://www.mysql.com/news-and-events/press-release/release_2005_45.html

MySQL Enables Tellme to Reduce Costs & Maintain High Availability
http://www.mysql.com/news-and-events/news/article_1198.html

Utel handles 10,000 Requests per Second Using a Scale out Deployment of MySQL Network
http://www.mysql.com/news-and-events/news/article_1198.html

PortaOne Delivers VoIP Billing with MySQL
http://www.mysql.com/why-mysql/case-studies/mysql-portaone-casestudy.php

Bredbandsbolaget (B2) Makes the Connection with MySQL Cluster
http://www.mysql.com/why-mysql/case-studies/mysql-b2-casestudy.php

Matanuska Telephone Association Relies on MySQL for its Most Critical Data
http://www.mysql.com/why-mysql/case-studies/mysql-mta-casestudy.php

For more information about companies in the telecommunications industry making use of MySQL, please visit:

http://www.mysql.com/industry/telecom/

### *Lower TCO with MySQL*

For more information on how MySQL can help your organization lower its database TCO, please see:

http://www.mysql.com/tco/

## About MySQL, AB

MySQL AB develops, markets, and supports a family of high performance, affordable database servers and tools. The company's flagship product is MySQL, the world's most popular open source database, with more than six million active installations. Many of the world's largest organizations, including Google, Sabre Holdings, The Associated Press, Suzuki and NASA, are realizing significant cost savings by using MySQL to power web sites, business-critical enterprise applications and packaged software. MySQL AB is a second generation open source company, and supports both open source values and corporate customers' needs in a profitable, sustainable business. For more information about MySQL, please go to http://www.mysql.com/