Deep Dive on Informix

Kevin Brown, Informix Chief Architect

kbrown3@us.ibm.com

Agenda

- Informix TimeSeries

- Informix Ultimate Warehouse Edition (IUWE)

- Informix Genero Edition

TimeSeries

Overview

- Why do we need Time Series?

- A little technology
  - Background on IBM Informix relational database with time series support
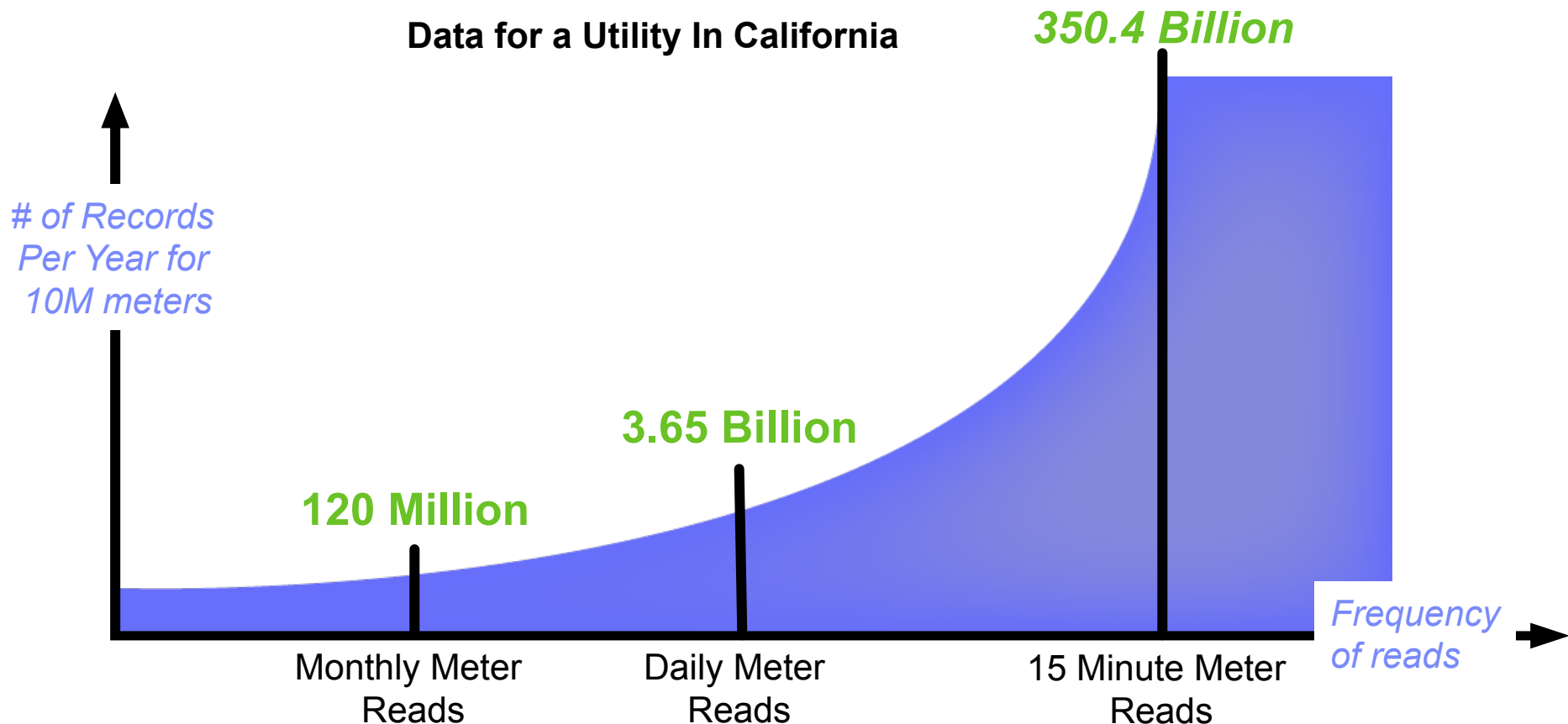
- Customer examples

Utility-Scale Smart Meter Deployments, Plans & Proposals*

September 2010

Deployment for >50% of end-users

Deployment for <50% of end-users

*This map represents smart meter deployments, planned deployments, and proposals by investor-owned utilities and large public power utilities.

http://www.edisonfoundation.net/IEE/   © 2010 The Institute for Electric Efficiency

Example of Changing Storage Requirements

Changing Workloads For 10 Million Smart Meters:

Today – Each meter is read once per month
Very soon – Each meter is read once every 15 minutes
Regulations – Need to keep data on line for 3 years (PUC) and, perhaps, save for 7 years

Data for a Utility In California

350.4 Billion

# of Records Per Year for 10M meters

3.65 Billion

120 Million

Monthly Meter Reads

Daily Meter Reads

15 Minute Meter Reads

Frequency of reads

Keeping up with Smart Meter Data

Large amounts of data causes problems in 2 areas:

1. Storage management
    *   Will get expensive and cumbersome to maintain

2. Query performance
    *   Compliance Reports must be completed before the end of each day
    *   Customer portal queries must be handled in a timely manner
    *   Customer billing

Introducing IBM Informix Relational Database

- **Why IBM Informix?**
  - Low cost/Low administration
    - Manage thousands of servers with one database administrator
    - Many installations have no DBA's

  - High performance
    - Insert 100's of thousands of records per second
    - Analytic functions not available in other database products

  - High Availability
    - Scale up, scale out, and disaster recovery

  - Native time series data support
    - Load and analyze time series data

"The idea was to run the project in three cycles, and use a different type of analysis in each cycle, to see if we could draw any conclusions in terms of how to promote change in the way people view their energy consumption. With help from the IBM Hursley team, we quickly found that Informix TimeSeries could deliver spectacular results." Clive Eisen, Chief Technology Officer at Hildebrand.

Key Strengths of Informix TimeSeries

- Performance
  - Extremely fast data access
    - Data clustered and sorted by time on disk to reduce I/O
  - Handles operations hard or impossible to do in standard SQL
  - Continuous Real-Time and Batch Data Loaders

- Space Savings
  - Typically saves 50% space over standard relational layout

- Toolkit approach
  - Allows users to develop their own algorithms to run in the database
  - Algorithms running in the database leverage the buffer pool for speed

- Easier
  - Conceptually closer to how users think of time series

Typical Relational Schema for Smart Meters Data
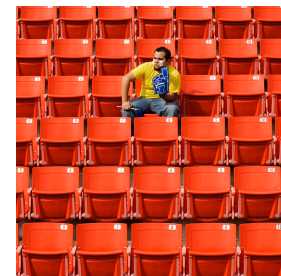
Index

Smart_Meters Table

Table Grows →

mtr_id	Time	KWH	Voltage		ColN
1	1-1-11 12:00	Value 1	Value 2	....	Value N
2	1-1-11 12:00	Value 1	Value 2	....	Value N
3	1-1-11 12:00	Value 1	Value 2	....	Value N
...	...	...	...	....	...
1	1-1-11 12:15	Value 1	Value 2	....	Value N
2	1-1-11 12:15	Value 1	Value 2	....	Value N
3	1-1-11 12:15	Value 1	Value 2	....	Value N
...	...	...	...	....	...

- Each row contains exactly one record = billions of rows
- Additional indexes are required for efficient lookups
- Data is appended to the end of the table as it arrives
- Meter Id's stored in every record
- No concept of a missing row

Same Table using an Informix TimeSeries Schema

Smart_Meters Table

mtr_id	Series
1	[(1-1-11 12:00, value 1, value 2, …, value N), (1-1-11 12:15, value 1, value 2, …, value N), …]
2	[(1-1-11 12:00, value 1, value 2, …, value N), (1-1-11 12:15, value 1, value 2, …, value N), …]
3	[(1-1-11 12:00, value 1, value 2, …, value N), (1-1-11 12:15, value 1, value 2, …, value N), …]
4	[(1-1-11 12:00, value 1, value 2, …, value N), (1-1-11 12:15, value 1, value 2, …, value N), …]
…	…

Table grows ⟹

- Each row contains a growing set of records = one row per meter
- Data append to a row rather than to the end of the table
- Meter Ids not stored in individual records
- Data is clustered by meter id and sorted by time on disk
- Missing values take no disk space, missing interval reads take 2 bytes

Real Customer Comparison TimeSeries vs. Relational (Major Texas Power Distributor)

- Simulated Environment
  - 1 million meters
  - 90 days worth of meter data
  - 15 minutes intervals
  - 200 locations
  - 500 feeders
  - 34 substations

- Hardware/OS Used
  - Power7 with 2 sockets each with 8 cores
  - 64 bit SUSE Linux v11
  - 128 GB of memory
    - Memory actually needed = 44GB
  - 6 disks dedicated to the database
    - Only 350GB disk space used by database
    - 2 additional disks for OS and input file staging

- Software Used
  - Informix Ultimate edition
  - Informix TimeSeries

Why Did they Contact Us?

- **Competitor was barely able to load and process the data in 24 hours**
  - It was taking the competitor about 5-7 hours to load and validate the data for 1 million meters
  - The *ERCOT compliance reports were each taking many hours to run
  - They were having problems running reports while data was being loaded

- **Customer was looking for ways to cut their costs**
  - Competitor used about 1.3 TB to store 90 days worth of data
    - Estimate for competitor to handle 3 years of data for 3.5 million meters was about 55 TB
  - Customer wanted to do more with the hardware they had
    - Process the data more quickly to allow other applications to run against the data

- **Customer was worried about their future**
  - In the next 1 to 2 years they expect to expand to manage 3.5 million meters
    - Their current 73 billion records stored would become 220 billion records stored
  - Even if the competitor scaled linearly there would not be enough time in the day to read and process all this data

Results of the POC with Informix TimeSeries

- Informix took about <u>18 minutes</u> to validate and load a day's worth of data for 1 million meters
  - Competitor took about 5 <u>hours</u>

- Informix took about <u>6 minutes</u> for each mandatory ERCOT compliance report <u>and about 25 seconds</u> if the data was already cached in memory
  - Competitor took from <u>2 to 3 hours</u> depending on the report

- Disk space used by Informix was about <u>350GB</u>
  - Competitor used about <u>1.3TB</u> for the POC
    - Their estimate for storing 3 years worth of 3.5 million meters was <u>55 TB</u>
    - Our estimate for 3 years worth of 3.5 million meters using the Informix TimeSeries was <u>15 TB</u>

- Results were very linear for Informix
  - Better results if you increase cpus and storage
  - If less performance is OK then cpus and storage can be reduced

"We are committed to improving energy efficiency by adopting the latest digital technologies providing Smart Metering solutions to our customers. Our major challenges are the significant storage space and performance required to manage the data collected by the smart meters. With Informix and its native support for time series data, we believe we will meet both of these challenges. Our initial testing has shown that with an Informix based solution we are able to reduce the storage requirements by __two thirds__ and speed the query __performance up to 60 times compared to the existing solution__."

Director Technology, Strategy, & Architecture

2011

Client Success: Hildebrand

hildebrand

Hildebrand is a technology consultant company on the Digital Environment Home Energy Management System (DEHEMS) project. The Hildebrand team was asked by the UK government to find a way to scale up its energy monitoring solution and enable it to monitor three million homes.

What's Smart?

- **Energy management thru real time monitoring**
- **Ability to monitor scales to over 3 million homes**
- **Reduced energy**

Business Benefits

- **Helping people make better decisions about energy efficiency in the home.**
- **Collect, store and analyse up to • 50,000 data points per second**
- **Delivers high performance on low-cost hardware by leveraging Informix time series data management technologies.**

Hildebrand: 3 Million Meters

- Test involved 3,000,000 Homes
  - Data generated every **6 seconds**!

- Up to 26 values recorded
  - Meter ID
  - Timestamp
  - 3 Electricity phases
  - 1 Gas reading
  - 20 Individual electrical sockets in the house

- Data collected every 6 seconds
  - Aggregated to per-minute readings
  - Minute readings bulk-loaded into Informix every 10 minutes
  - Average load was about 50,000 inserts per second

- **Hardware/Software Used**
  - Intel with 8 cores running:
    - 64 bit SUSE Linux v10
    - 16 GB of memory
  - Informix workgroup edition
  - Hildebrand software

Consumer Education

Hildebrand Results/Conclusions

- People want to be "green"

- Immediate impact in behaviour change

- New behaviour seems to be sustained

- Big scope for community functions

- People want to know more

- Target of 20% savings is very achievable

IBM

AMT/SYBEX
Proving the concept for smart metering data management

AMTSybex
Enabling essential industries

- **The Need:**
  - Extend AMT/Sybex's Data Transfer Solution to:
    - Load, validate, store, and provide smart meter interval and event data to external system

- **The Challenge:**
  - Process the enormous volume of data in a timely manner
  - Not to require a huge investment in new hardware

- **The Solution:**
  - Combined effort with IBM Research and IBM Informix
  - Informix TimeSeries provides the core capabilities to store and process the meter and event data:
    - VEE
    - Real-time energy monitoring
    - Analytics for developing new tariff rates
    - Help to smooth peaks in demand

"We owe a great deal to IBM, both for the Informix technology itself, and for the fantastic support from all levels of the organisation."
— *Gordon Brown, DTS Product Owner, AMT-SYBEX*

Solution components:

- IBM® Informix® TimeSeries™
- IBM Research

AMTSybex
Enabling essential industries

2011

# AMT/Sybex Tests and Performance Measurements

The main tests for AMT-SYBEX were to prove key business functions at high volume:

- Can high volumes of data be loaded into Smart DTS?
- Can data be analyzed and processed in Smart DTS in a timely manner?

To facilitate these requirements, the following tests were carried out:

- These results are for 10 million meters storing data every ½ hour data for one day.

Module	Time	Readings/intervals per second
Technical Validation and Transformation	**13 minutes**	**>600,000**
High Speed TimeSeries database load (with full logging)	**50 minutes**	**>150,000**
Validation and Estimation	**33 minutes**	**>240,000**
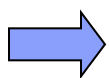
→ Full processing end to end for 10 million meter points with half-hourly interval data on a single mid-range P-series 8 CPU server is just over 1 ½ hours

AMTSybex
Enabling essential industries

IUWE

Informix Ultimate Warehouse Edition

Informix Warehouse: Then and Now

Warehouse Accelerator

Star Join Optimization
Multi-index Scan
New Fragmentation
Fragment Level Stats
Storage Provisioning

External Tables

Cognos integration
  - Native Content Store on IDS
SQL Merge

Informix Warehouse with
Storage Optimization/
Compression

Informix Warehouse
Feature
  - SQW
  - Data Modeling
  - ELT/ETL

Now Introducing… Informix Ultimate Warehouse Edition

What it is

- New Informix edition for warehouse
- Package contains:
  - Informix Ultimate Edition
  - Informix Warehouse Accelerator (IWA)*
  - IBM Smart Analytics Optimizer Studio
  - Compression Feature included

What IWA does

- Compresses and processes data mart entirely in memory
- Uses a deep columnar approach for optimizing performance
- Runs as an add-on to Informix

Benefits

- Order of magnitude or more performance gains
- Transparent to BI apps – queries continue to run against Informix
- No maintenance

*Informix Warehouse Accelerator requires a Linux Intel system as it is relies on optimizations in that environment

IWA requires you to do…

No Query Tuning and Optmizer Hints

No Database tuning

No Index creation, reorganization

No Update Statistics

No Partioning/Fragementation

No Storage Management/Page size configuration

No Database/schema Changes

No Application Changes

No Summary Tables/Materialized Views

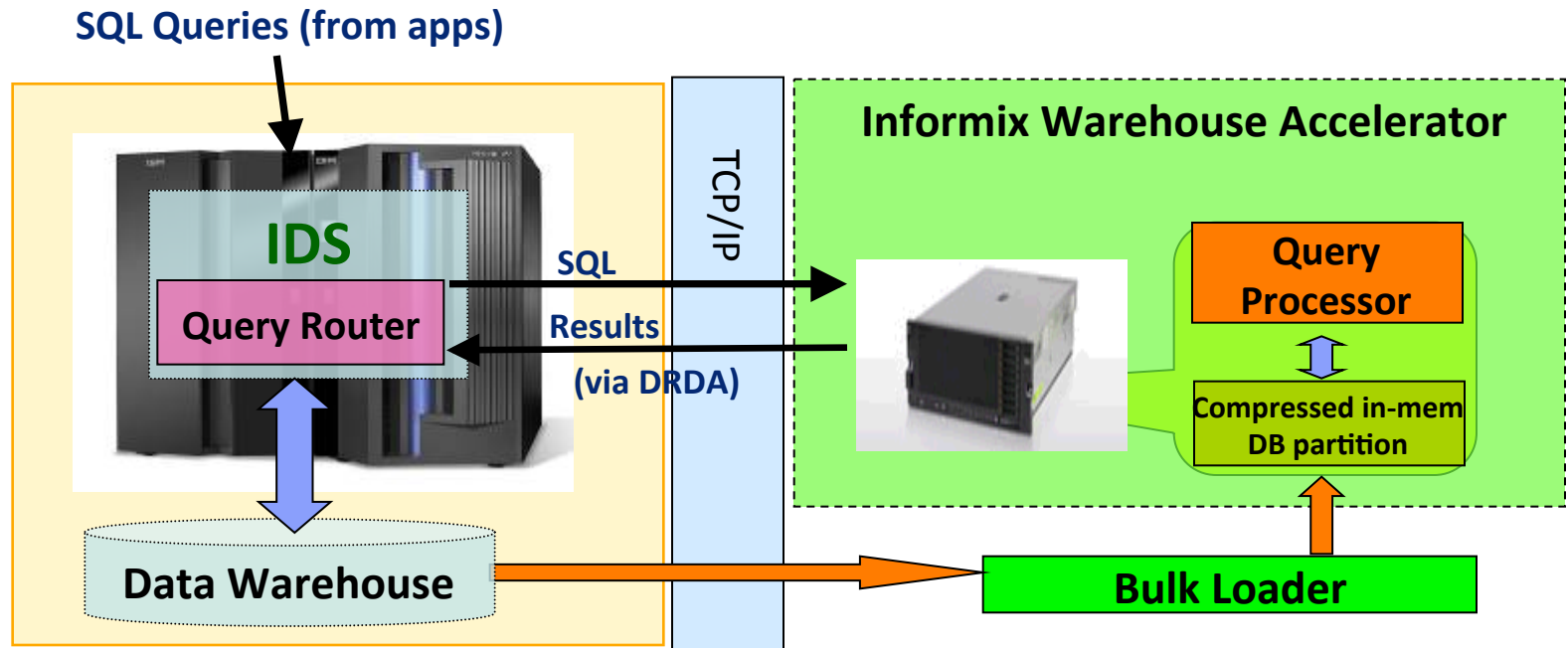No Buying more expensive Hardware

No Change of expectations

Power of Simplicity!

IWA: Breakthrough Technologies for Performance

Extreme Compression
Up to 2/3 reduction in space

Row & Columnar Database
Row format within IDS for transactional workloads and columnar data access via IWA for OLAP-style queries.

Multi-core and Vector Optimized Algorithms
Avoids locking and synchronization

In Memory Database
Compression allows huge databases to be completely memory resident thus eliminating disk I/O

7
1
6
2
5
3
4

Predicate evaluation on compressed data
Decompression not required to evaluate predicates

Frequency Partitioning
Automatic Horizontal and Vertical Partitioning quickly eliminates data not relevant to scan

Massive Parallelism
All CPU cores are used in parallel for queries

Informix Warehouse Accelerator Configuration

IDS:

- User need not change SQL or apps.
- Routes SQL queries to accelerator as needed and reads back results
- Can always run query in IDS, e.g., if estimated execution time is very short

Informix Warehouse Accelerator:

- Communicates with IDS via TCP/IP & DRDA
- Analyzes, compresses, and loads a portion of the Informix warehouse into IWA
- Processes routed SQL query and returns answer to IDS

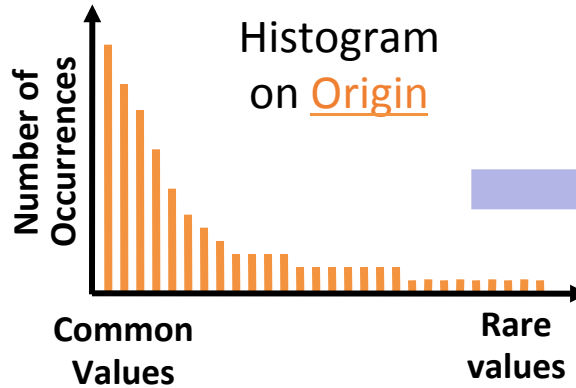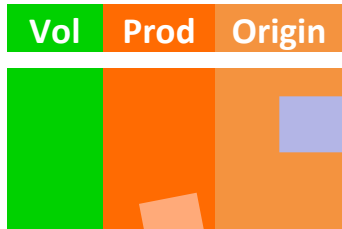# IWA Sweet Spot: Queries against Star and Snowflake Schemas
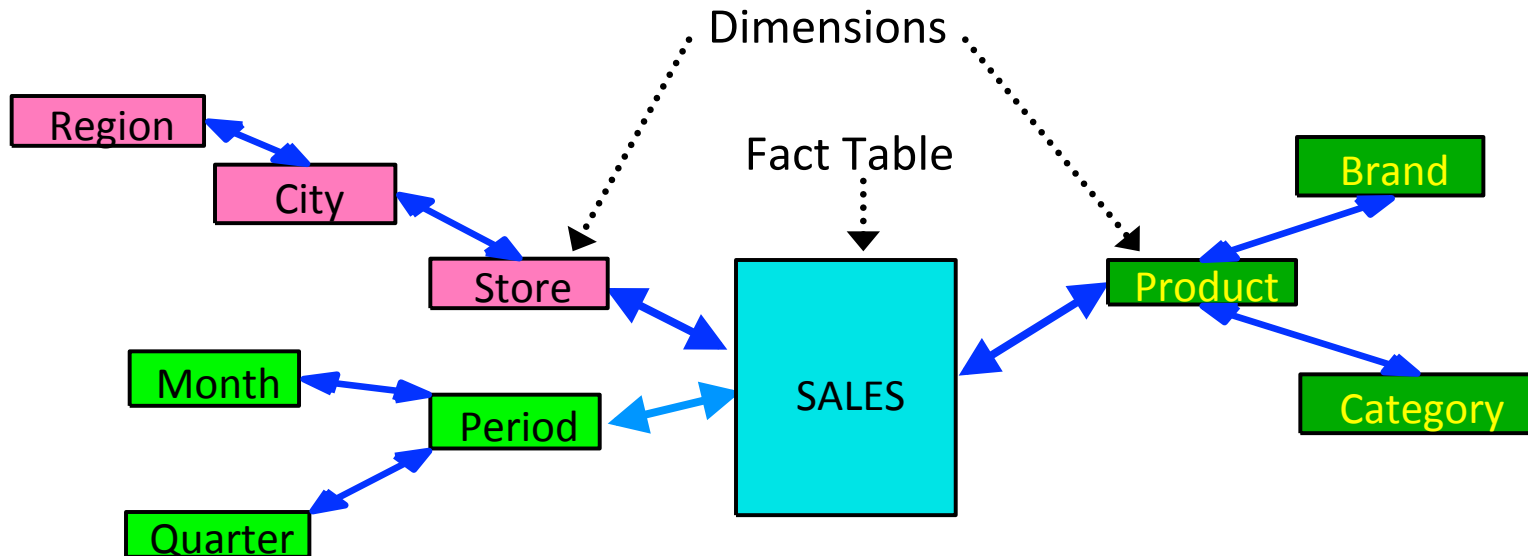
Complex, ad hoc queries that typically
– Look for trends, exceptions to make actionable business decisions
– Touch large subset of the database (unlike OLTP)
– Involve aggregation functions (e.g., COUNT, SUM, AVG,…)
– **The "Sweet Spot" for the IWA!**

# Compression: Frequency Partitioning

Trade Info (volume, product, origin country)

Vol	Prod	Origin

Histogram on Origin

Number of Occurrences

Common Values → Rare values

Column Partitions

China USA | GER, FRA, … | Rest

Histogram on Product

Top 64 traded goods – 6 bit code

Rest

Origin

Product

| Cell 1 | Cell 3 | Cell 4 |
| Cell 2 | Cell 5 | Cell 6 |

Table partitioned into Cells
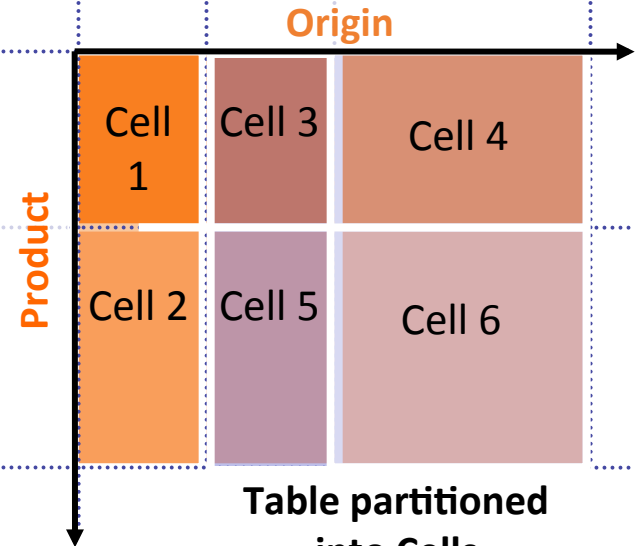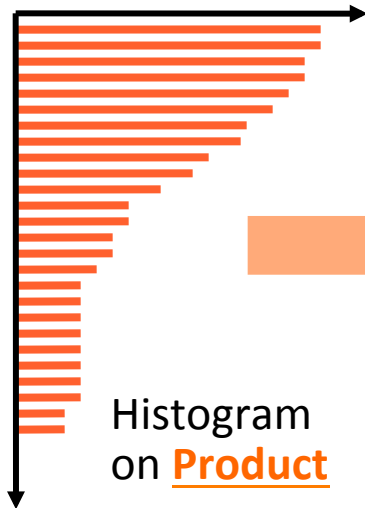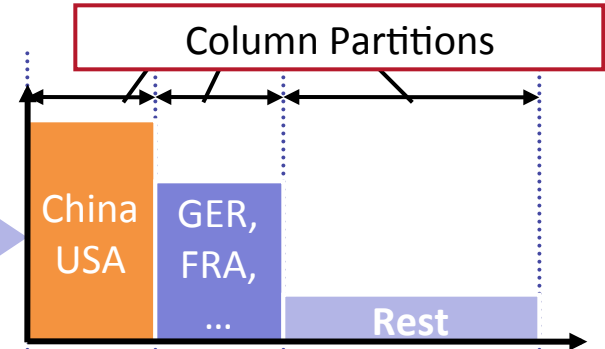
- **Field lengths vary between cells**
  - Higher Frequencies ➔ Shorter Codes (Approximate Huffman)
- **Field lengths fixed within cells**

IBM Smart Analytics Optimizer Studio (ISAO)
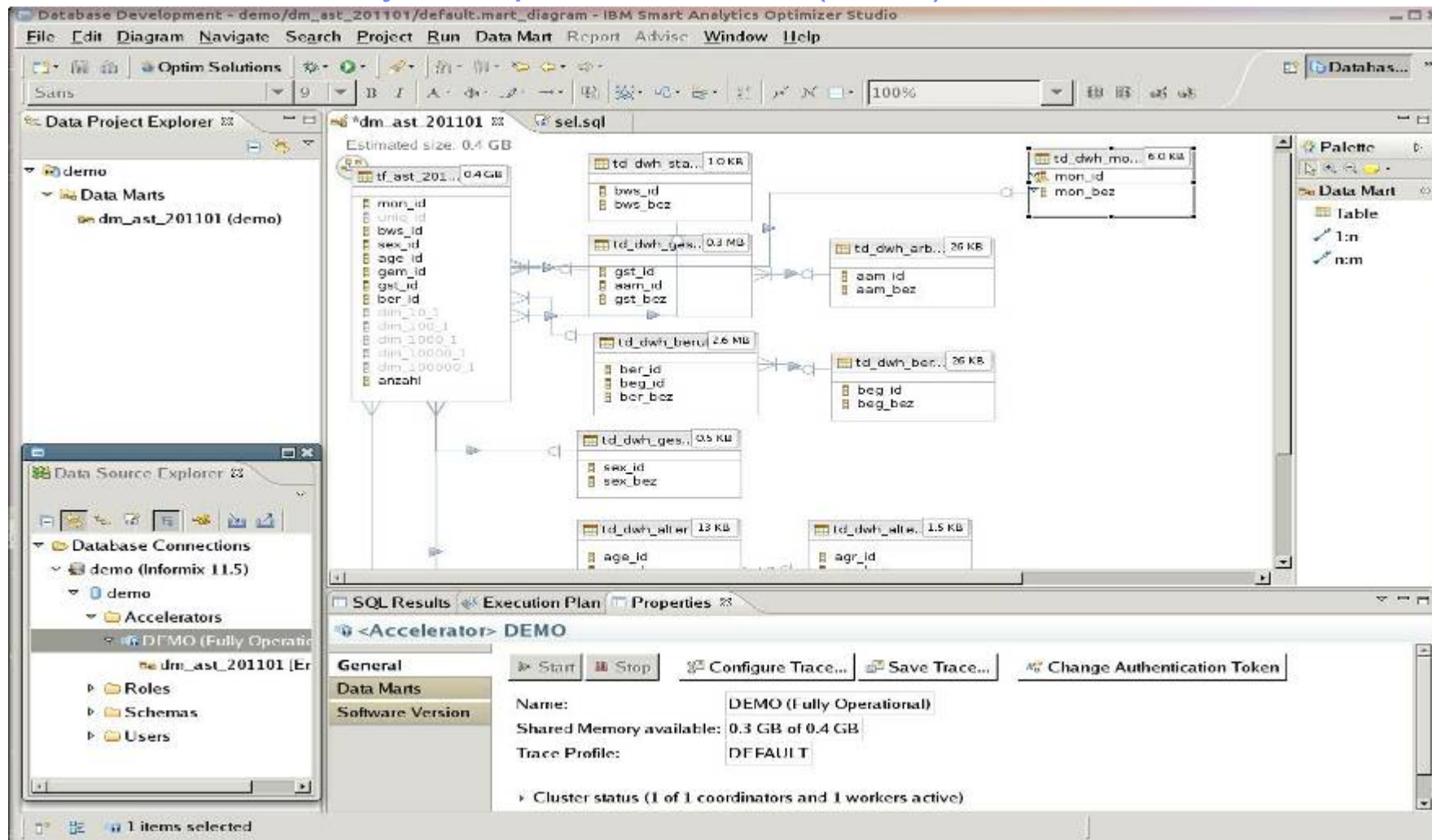
**Easy to use graphical tool for data mart configuration for Linux and Windows
(included with IUWE)**

Case Study #1: Major U.S. Shoe Retailer

- Top 7 time-consuming queries in Retail BI and Warehouse: (Against 1 Billion row Fact Table)

Query	IDS 11.5	IDS 11.7 IWA
1	22 mins	4 secs
2	1 min 3 secs	2 secs
3	3 mins 40 secs	2 secs
4	30 mins & up	4 secs
5	2 mins	2 secs
6	30 mins	2 secs
7	45 mins & up	2 secs

"Our Retail users will be really happy to see such a huge improvement in the queries processing timings."

"This IWA extension to IDS will really bring value to the Retail BI environment."

Advanced Data Tools Tests

Run	Query	Type of Query	IDS Only	IDS & IWA	Improvement	Rows Return
1	Query12	Scan - Select First 1000	105m7.730	9m48.071	**10.7261**	1000
2	Query13	Index - by Dim	0m0.116	0m11.605	0.0100	9
3	Query14	Index - by Dim	0m0.055	0m11.971	0.0046	9
4	Query15	Index - by Dim	0m8.345	0m4.469	**1.8673**	9
5	Query0	Scan - Select First 1000	106m44.474	0m20.946	**305.7612**	1000
6	Query10	Index - by Dim	0m4.817	0m6.062	0.7946	1
7	Query11	Index - by Dim	0m3.430	0m6.068	0.5653	1
8	Query1	Scan - Select First 100	63m33.083	1m13.501	**51.8780**	100
9	Query2	Scan - Select First 100	65m17.075	1m29.518	**43.7574**	100
10	Query3	Scan - Sum by Dim	87m47.842	0m17.207	**306.1453**	3107
11	Query4	Scan - Select First 100	53m57.169	0m14.162	**228.5813**	100
12	Query5	Index - by Dim	0m0.049	0m12.692	0.0039	0
13	Query6	Scan - Select First 1000	1m48.886	0m9.495	**11.4677**	1000
14	Query7	Scan - by Dim w Group by	0m15.855	0m9.171	**1.7288**	26937
15	Query8	Scan - by Dim w Group by	0m14.846	0m2.347	**6.3255**	28358
16	Query9	Scan - by Dim w Group by	79m14.253	0m42.011	**113.1669**	523499
	Total in hours		**9hr 40min**	**15min 32sec**		
	Total in minutes					

2011

IWA Referenced Hardware Configuration

Intel(R) Xeon(R) CPU	X7560 @ 2.27GH 4 X 8
Memory	512G
6 disks	300 GB SAS hard disk drives each

Options:

- 4-processor, 4U rack-optimized enterprise server with Intel® Xeon® processors
- 8-core, 6-core and 4-core processor options with up to 2.26 GHz (8-core), 2.66 GHz (six-core) and 1.86 GHz (four-core) speeds with up to 16 MB L3 cache
- Scalable from 4 sockets and 64 DIMMs to 8 sockets and 128 DIMMs
- Optional MAX5 32-DIMM memory expansion (up to a total of 1.5 TB of memory)
- 16x 1.8" SAS SSDs with eXFlash or 8x 2.5" SAS HDDs

IBM Genero

IBM Informix Genero - What is the Offering?

- The offering is driven through a partnership between:

- Allows Informix 4GL users to deploy existing and new applications in:
  - Browser-based environments
  - GUI desktop environments
  - Mobile environments
  - Cloud environments

- Leverages the Four J's Genero product family:
  - Genero BDL with Web Services
  - Genero Application Server
  - Genero Desktop Client
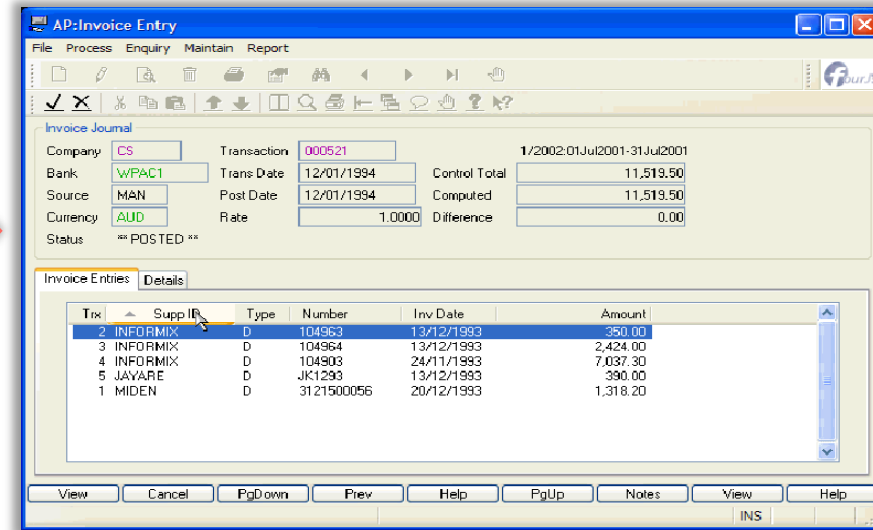 - Genero Report Designer and engine
  - Genero Studio server and client

What is the Offering?

Informix 4GL
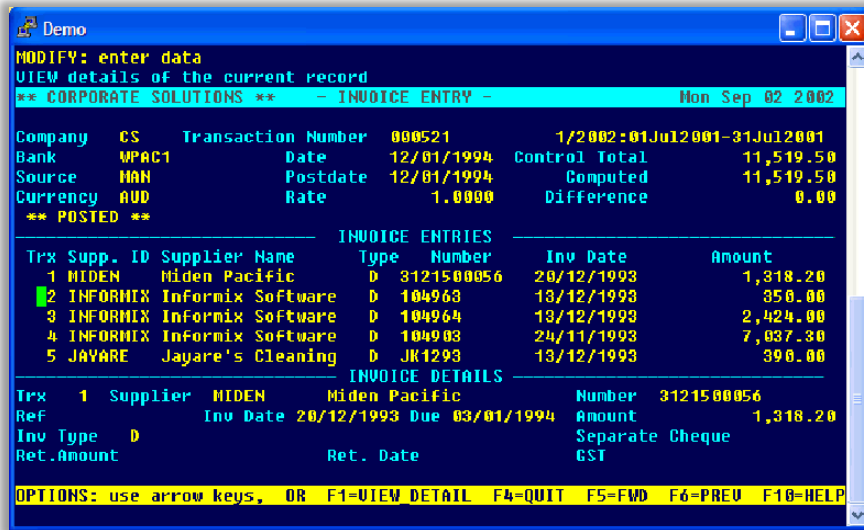
Informix Genero

Current Informix 4GL offerings:
- 4GL Compiler Development
- 4GL Interactive Debugger
- 4GL Compiler Runtime
- 4GL RDS Development
- 4GL RDS Runtime

➡ 4GL continues to be available

New Informix Genero offerings:
- Genero Developer Suite
- Genero Runtime Suite

2011

What is in the Genero Offering?

- **Modern Development Environment for 4GL**
  - Graphical Development Environment (Genero Studio):
    - Compiler, debugger, 4GL-aware editor
    - Graphical display form builder
    - Application Generator
    - Source code control

  - Graphical Report Writer (Genero Report Writer):
    - Graphical report layout designer

  - Deployment Options (Genero display clients):
    - Windows (native), Web, Mac, iPhone, Microsoft Silverlight

  - Web Services

  - Enhancements to the 4GL Language (Genero BDL)

 - Rich O/S platform availability (including Windows and Mac)
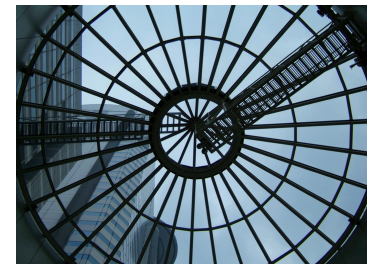
Genero Studio – Graphical IDE for 4GL
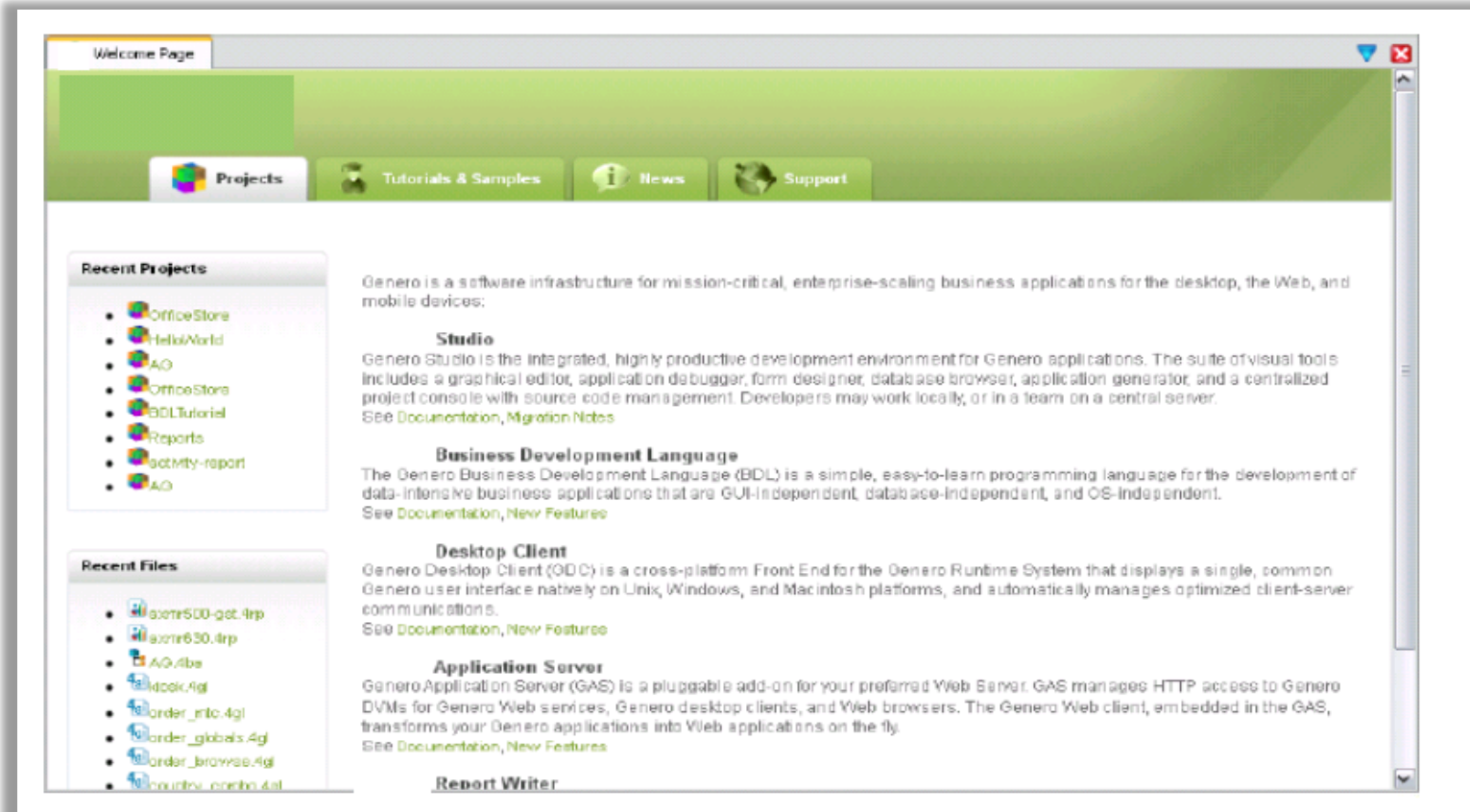
- Edit Code	- Design Forms
- Create Reports	- Debug applications
- Manage Projects	- Team Work (version control)
- Diff programs	- SOA and Web Services
- Application Generator	- Code Profiler

Genero Report Writer – Fast, Streaming, and Flexible

- Enterprise reports

- Streaming architecture

- Scalable

- Dynamic layouts

- Formats supported:
  - PDF
  - HTML
  - Excel
  - Others
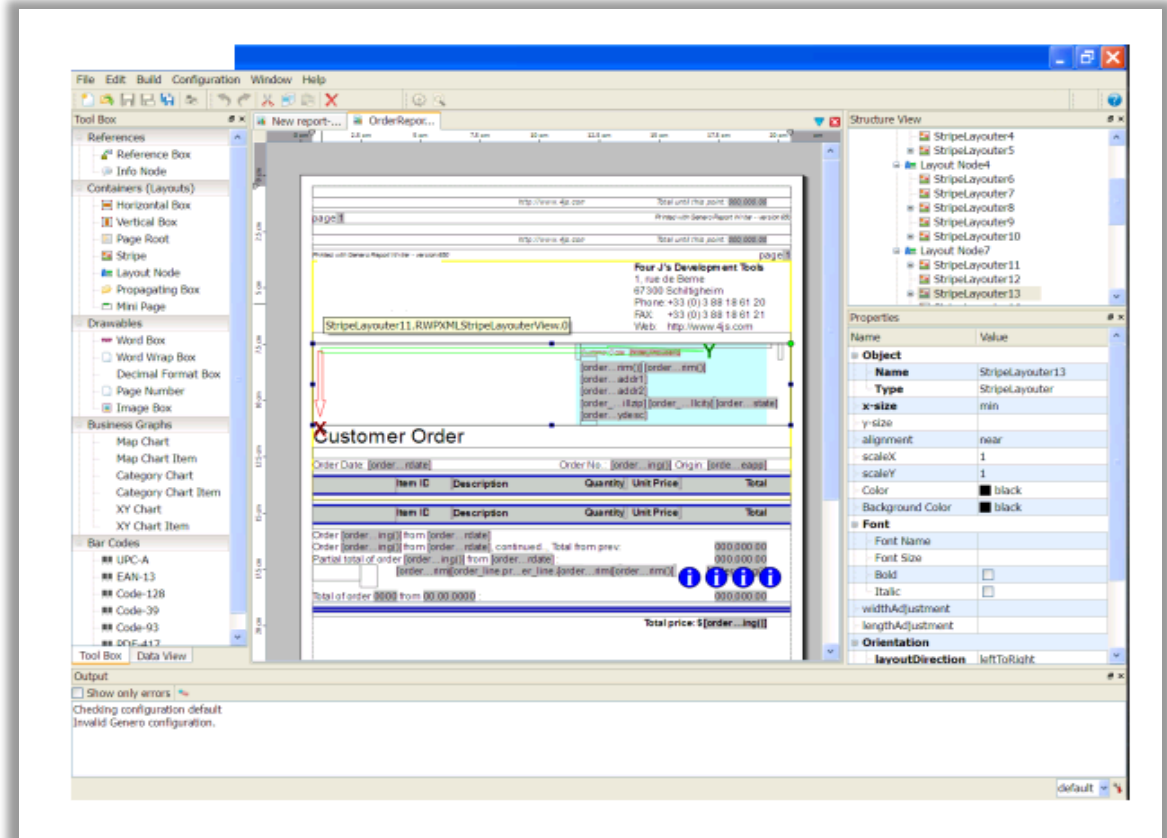
Flexible Development across many Platforms

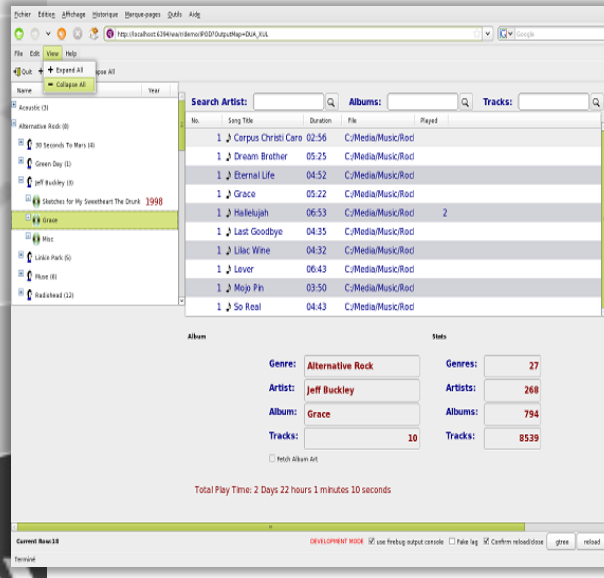One 4GL code base can run across
many display environments!

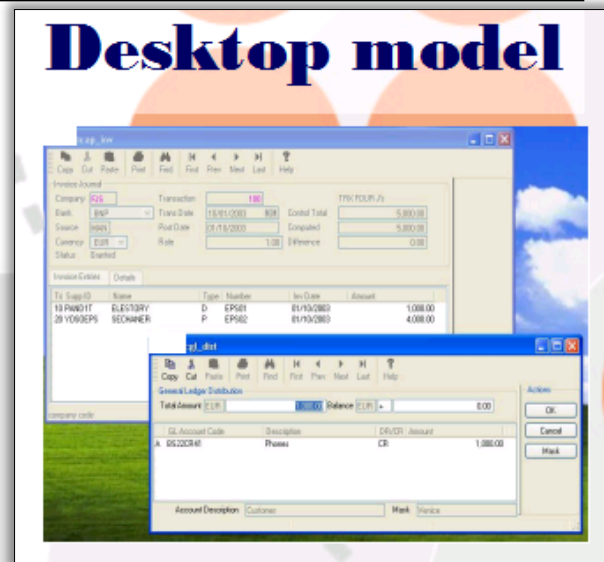**Desktop model**

Pocket PC

Mac

Java

Linux

Windows

HTML

User Interface

XML

Java

IIS7
internet information services

4GL to Genero - Conversion Case Studies

What is the process?

1. Re-use existing 4GL source code

2. Simply recompile existing code

3. Perform customization as needed

4. Deploy anywhere!

Project A:
- Perform 1:1 conversion
- Very short term - three weeks to convert
- Conversion 100% executed by Adaptris
- Future development performed by customer

  Key metrics:
  - 354 programs
  - 3.023 modules
  - 625 screens
  - 1.174.100 lines of source code

Project B:
- Conversion with significant enhancements
- Medium term – two man months to convert
- Conversion executed in tight collaboration at customer site
- Future development performed by customer

  Key metrics:
  - 242 programs
  - 1.522 modules
  - 596 screens
  - 574.684 lines of source code

kbrown3@us.ibm.com