Best Performance and Design Practices for Analytic Applications

Dave Beulke

Dave Beulke and Associates

Session code:

Columbus, Detroit & Cleveland
September 11, 12 & 13, 2018

Cross Platform

I am honored to have been a presenter at all 30 years of IDUG

2018 – Philadelphia **- Security Best Practices Volume II**
-Best Design and Performance Practices for Analytics
2017 – Anaheim -Understand IDAA Performance and Justify an IDAA Appliance
2016 – Austin Performance Enterprise Architectures for Analytic Design Patterns
How to do your own Db2 Security Audit
2015 - Valley Forge Db2 Security Practices
Big Data Performance Analytics Insights
2014 – Phoenix Big Data SQL Considerations
2013 – Orlando Big Data Disaster Recovery Performance
2012 – Denver Agile Big Data Analytics
2011 – Anaheim Db2 Temporal Tables Performance Designs
2010 - Tampa - Java DB2 Developer Performance Best Practices
2009 – Denver -Java Db2 Perf with pureQuery and Data Studio
Improve Performance with Db2 Version 9 for z/OS
2008 – Dallas - Java pureQuery and Data Studio Performance
2007 - San Jose - Developing High Performance SOA Java Db2 Apps
Why I want Db2 Version 9
2006 - Tampa - Class - How to do a Db2 Performance Review
Db2 Data Sharing
Data Warehouse Designs for Performance
2005 – Denver - High Performance Data Warehousing
2004 – Orlando – Db2 V8 Performance
President of IDUG
2003 - Las Vegas - Db2 UDB Server for z/OS V8 Breaking all the Limits
Co-author IBM Business Intelligence Certification Exam

2002 - San Diego - Db2 UDB for LUW 8 - What is new in Db2 Version 8
Data Warehouse Performance
2001 – Orlando -Data Sharing Recovery Cookbook
Designing a Data Warehouse for High Performance
Co-authored the first IBM Db2 z/OS Certification Exam
2000 – Dallas - Db2 Data Warehouse Performance Part II
1999 – Orlando - Store Procedures & Multi-Tier Performance
Developing your Business Intelligence Strategy
Evaluating OLAP Tools
1998 - San Francisco - Db2 Version 6 Universal Solutions
Db2 Data Warehouse Performance
Db2 & the Internet Part II
1997 – Chicago - Db2 & the Internet
1996 – Dallas- Sysplex & Db2 Data Sharing
Best Speaker Award at CMG Conference Mullen Award
1995 – Orlando - Practical Performance Tips
Improving Application Development Efficiency
1994 - San Diego - Database Design for Time Sensitive Data &
Guidelines for Db2 Column Function Usage
1993 – Dallas - High Availability Systems: A Case Study &
Db2 V3: A First-Cut Analysis
1992 - New York -Db2 –CICS Interface Tuning
1991 - San Francisco - Pragmatic Db2 Capacity Planning for DBAs
1990 – Chicago - Performance Implication of Db2 Design Decisions
1989 – Chicago - Db2 Performance Considerations

Dave@davebeulke.com

- Member of the inaugural IBM Db2 Information Champions
- One of 40 IBM Db2 Gold Consultant Worldwide
- President of DAMA-NCR
- Past President of International Db2 Users Group - IDUG
- Best speaker at CMG conference & former TDWI instructor

- Former Co-Author of certification tests
  - Db2 DBA Certification tests
  - IBM Business Intelligence certification test

- Former Columnist for IBM Data Management Magazine

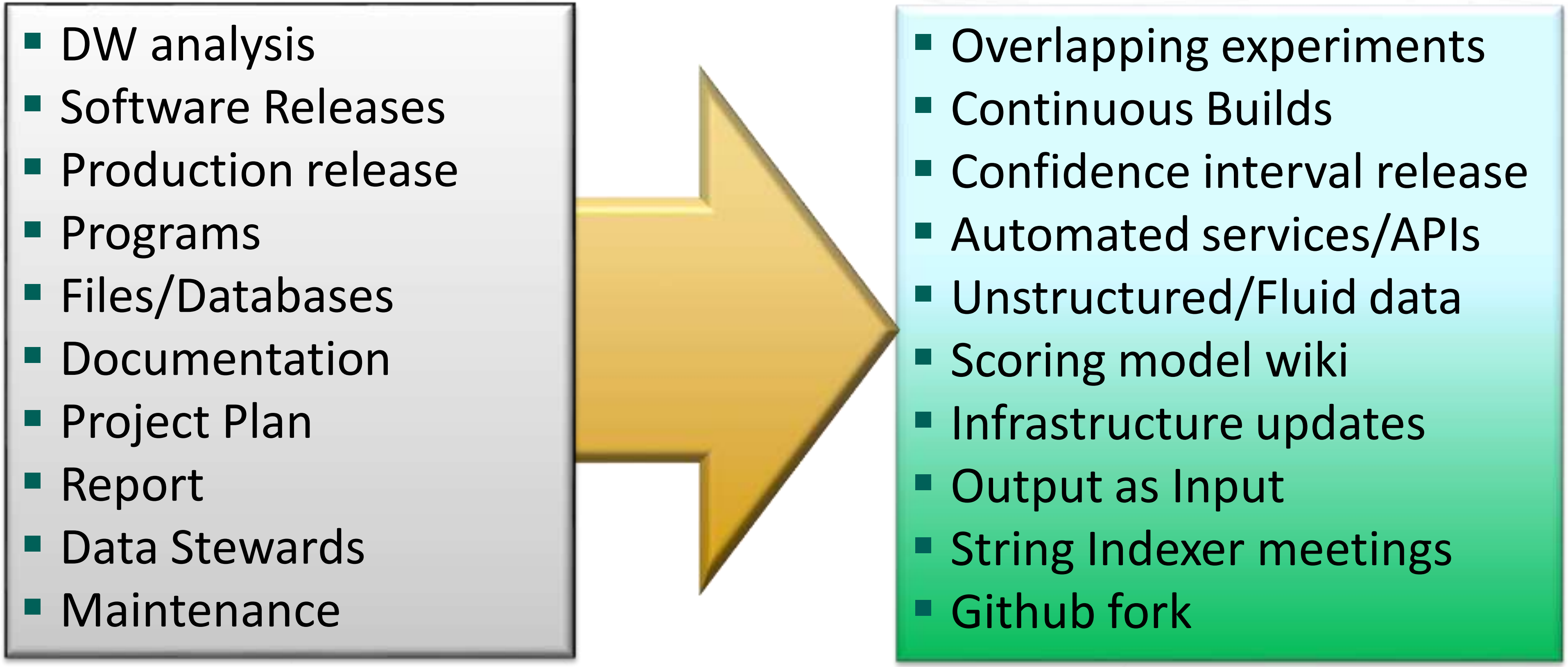
- Extensive experience in Big Data systems, DW design and performance
  - Working with Db2 on z/OS since V1.2
  - Working with Db2 on LUW since OS/2 Extended Edition
  - Designed/implemented first data warehouse in 1988 for E.F. Hutton
  - *Syspedia* for data lineage and data dependencies since 2001 –
    - Find, understand and integrate your data faster!

Proven Performance Tips:
www.DaveBeulke.com

- **Consulting**
  - **Security Audit & Compliance**
  - **Db2 Performance Review**
  - **CPU MLC Demand Reduction**
  - **Analytics & Database Design Review**
  - **Db2 12 Migration Assistance**
  - **Java Application Performance Tuning**

- **Educational Seminars**
  - **Java Security for Application Developers**
  - **Db2 Version 12 Transition**
  - **Db2 Performance for Java Developers**
  - **Data Warehousing Designs for Performance**
  - **How to Do a Java Performance Review**

World has changed; Still the same; New Names?



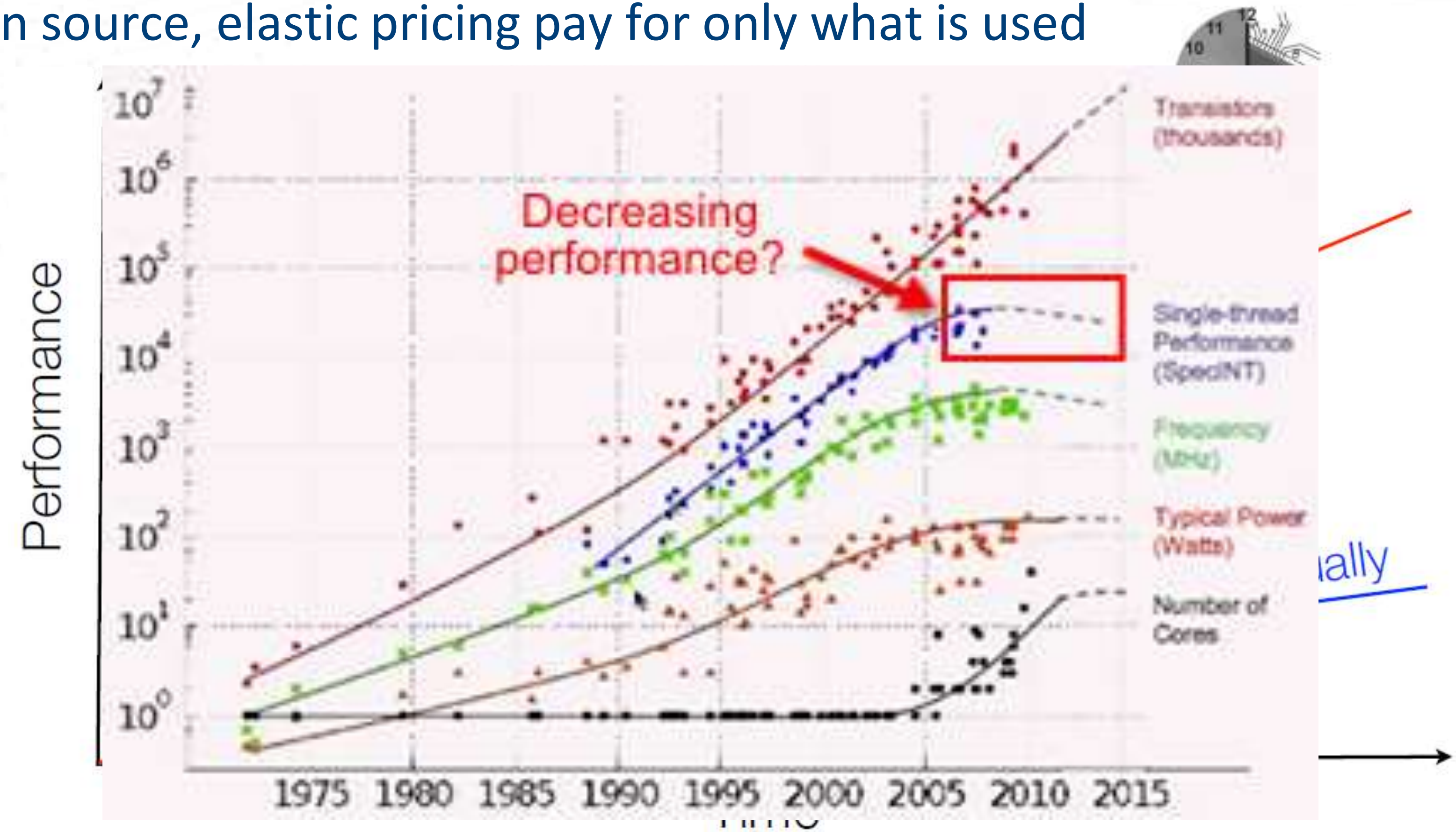
- DW analysis
- Software Releases
- Production release
- Programs
- Files/Databases
- Documentation
- Project Plan
- Report
- Data Stewards
- Maintenance

- Overlapping experiments
- Continuous Builds
- Confidence interval release
- Automated services/APIs
- Unstructured/Fluid data
- Scoring model wiki
- Infrastructure updates
- Output as Input
- String Indexer meetings
- Github fork

ML and AI still depend on good data management practices!

Moore’s Law, commodity everything and Cloud

- Cost of the hardware/software is non issue
  - Open source, elastic pricing pay for only what is used



Analysis of every situation - track everything

Scene from the book '*Snow Crash*' by Neal Stephenson (required reading at Facebook)

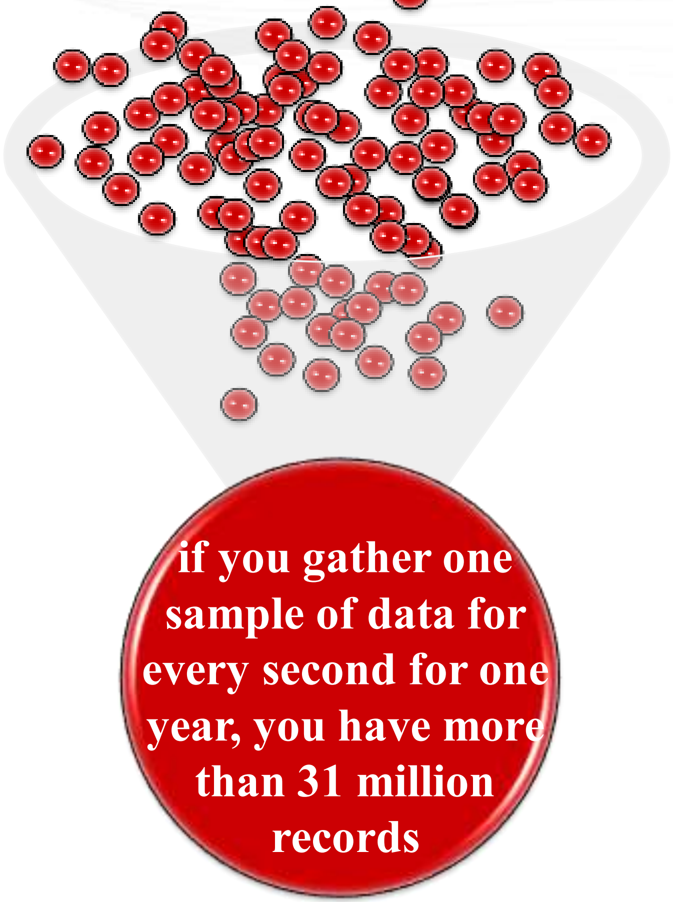
- Novel shows a world where the internet is replaced with the *Metaverse*, a shared virtual reality
- Y.T.'s mom is tracked by her employer as she reads a memo on a cost-saving program
  - Less than 10 min.: Time for an employee conference and possible attitude counseling.
  - 10-14 min.: Keep an eye on this employee; may be developing slipshod attitude.
  - 14-15.61 min.: Employee is an efficient worker, may sometimes miss important details.
  - Exactly 15.62 min.: Smartass. Needs attitude counseling.
  - 15.63-16 min.: Asswipe. Not to be trusted.
  - 16-18 min.: Employee is a methodical worker, may sometimes get hung up on minor details.
  - More than 18 min.: Check the security videotape, see just what this employee was up to (e.g., possible unauthorized restroom break).

- Y.T.'s mom decides to spend between fourteen and fifteen minutes reading the memo. It's better for younger workers to spend too long, to show that they're careful, not cocky. It's better for older workers to go a little fast, to show good management potential. She's pushing forty. She scans through the memo, hitting the Page Down button at reasonably regular intervals, occasionally paging back up to pretend to reread some earlier section. The computer is going to notice all this. It approves of rereading. It's a small thing, but over a decade or so this stuff really shows up on your work-habits summary

Cloud Security

- Technology bandwidth –
  - Regulatory drivers
  - Use it for DR and
    - Drive business growth competition
- Security impacts
  - PII, HIPPA, Masking, Encryption etc….
- Framework for business continuity
  - Physical to VM
  - VM to Physical
  - VM to VM
  - Logical sync point - Local or remote
  - File or transaction
  - Requirements/Money/Technology

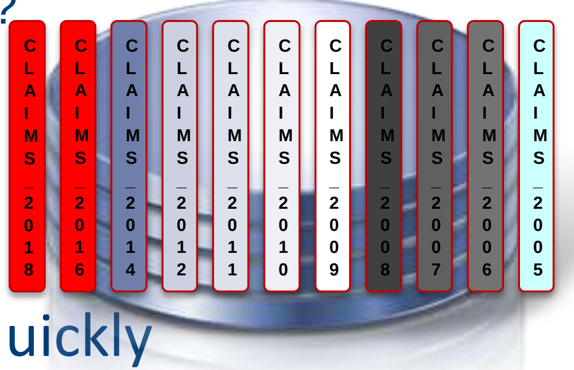
IoT - Sensor Data



if you gather one sample of data for every second for one year, you have more than 31 million records

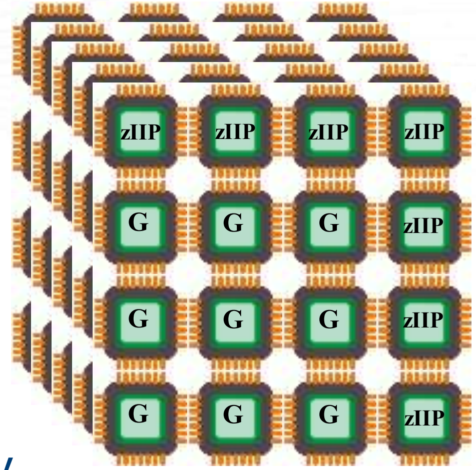
Best Practice for analytical database design

- Delineate physical objects I/O bound operations
  - Partition the database tables to minimize the data required for daily SQL
  - Use the thousands of partitions available for a design
    - How many parallel processes are your applications running today?



- Separate old data from new data
  - Current Year, Quarter, Week, Day
  - Temporal tables with the HISTORY tables
    - Complicates the SQL also can make a lot of data quickly
  - Materialized Query Table – YTD sales figures
    - Or composite tables to separate via TIME axis Year, AP, Quarter, Week, Day
    - Or composite tables to separate via Sales territory axis Country, Region, State, City, Zip code

Free CPU for parallelism



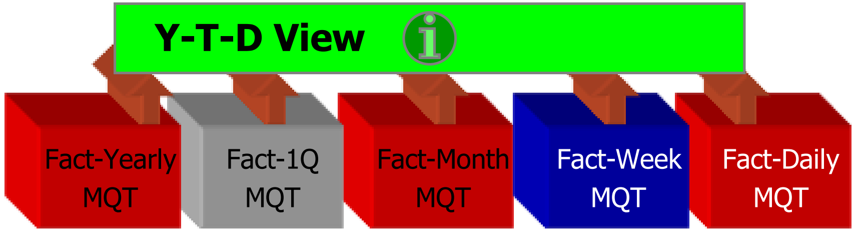
- Partitioning to leverage ***free zIIP*** more parallel processes
  - Same partitioning limit keys across multiple table spaces
    - Via Customer number across those related tables
    - Via Product SKU number across all the product related data

- Partitioning design leverages customer, product or time properly
  - The active partitions are only a segment of the entire table
  - Concentrates the I/O into the right sized portion of the database
  - Current history available - Ancient history is in database as AOT/archived easily

- Indexes (NPIs or DPSIs) are appropriately designed
  - Partitioned for parallelism and recovery time objectives (RTO)
  - Table clustered for SQL efficiencies

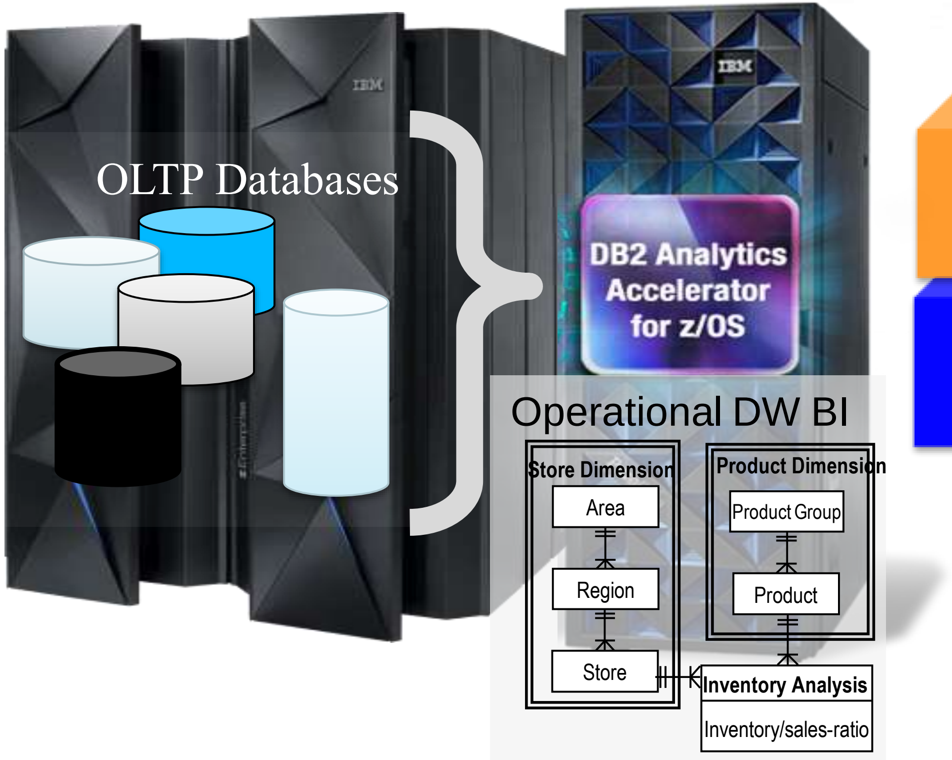
Best practice use MQT – 10 to 1000 times improvement!

- 5B rows per year–10 per 4k page= ½B pages
- MQT aggregates save large amounts of everything
  - Create aggregates for every possibility
    - “On Demand” information
    - Sales by department
    - Sales by zip code
    - Sales by time period – day/week/month/quarter/AP
  - All reporting and analysis areas
  - Trace usage to create/eliminate aggregates
- Total by month ½B I/Os versus 12 I/Os

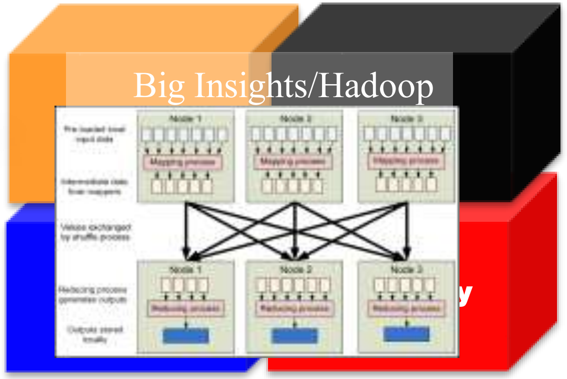


Diversity of systems, architectures and bigger data

- All types of options
- Many architectures
  - Matching business requirements to efficiency/costs



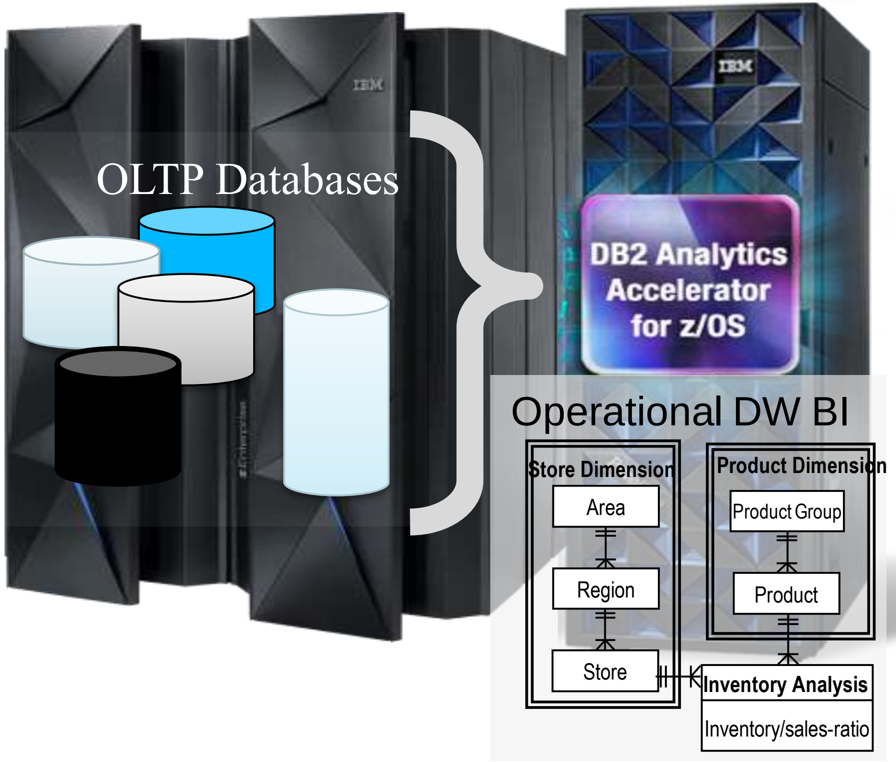
Cloud!



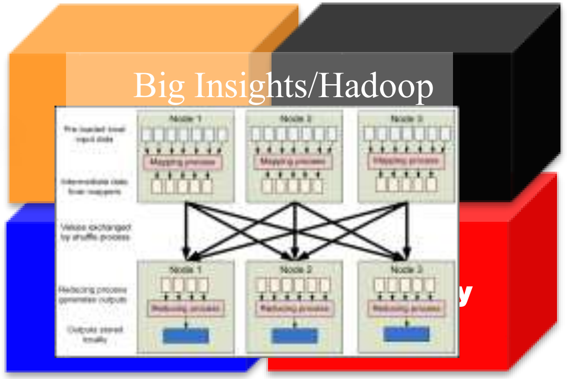
Now add ML and AI Analytics!

Big Data HTAP Architecture

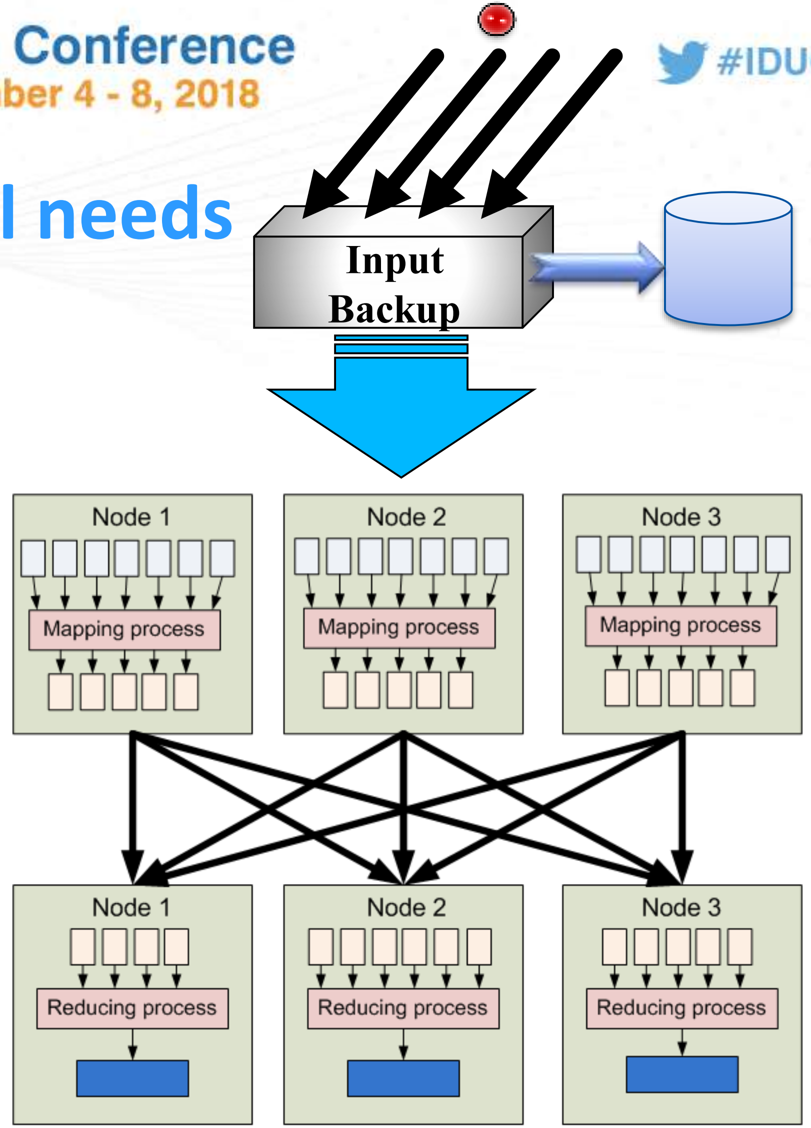
- Capacities- I/O & CPU
- Latency/Integrity
- All APIs & interfaces
  - JSON
- Security
- Disaster Recovery



Cloud!



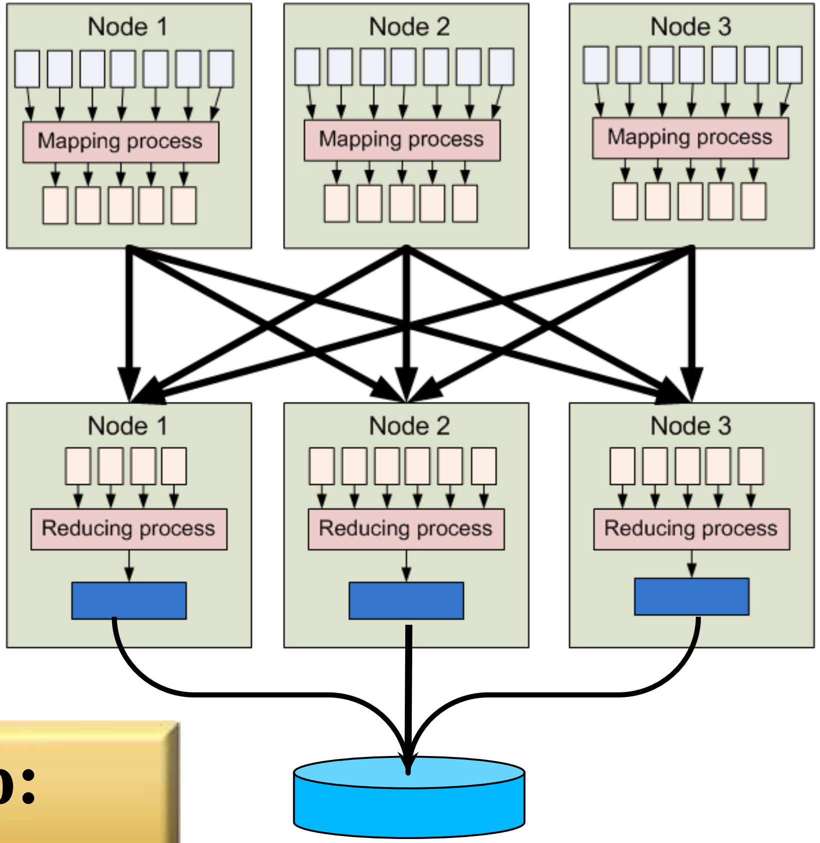
Hadoop's Disaster Recovery - special needs



- Hadoop Three Sections
  - Data, System & Configuration
- Biggest is input data
  - **Data is REPLICATED to 2 or 3 nodes**
  - Compression considerations
  - Best: backup as it comes in
  - Disk, Node, Rack, Site failures
    - Standard DR
- System/Application(s)
  - Frequent regular backups
- Configuration
  - Frequent regular backups

Hadoop's Disaster Recovery - special needs

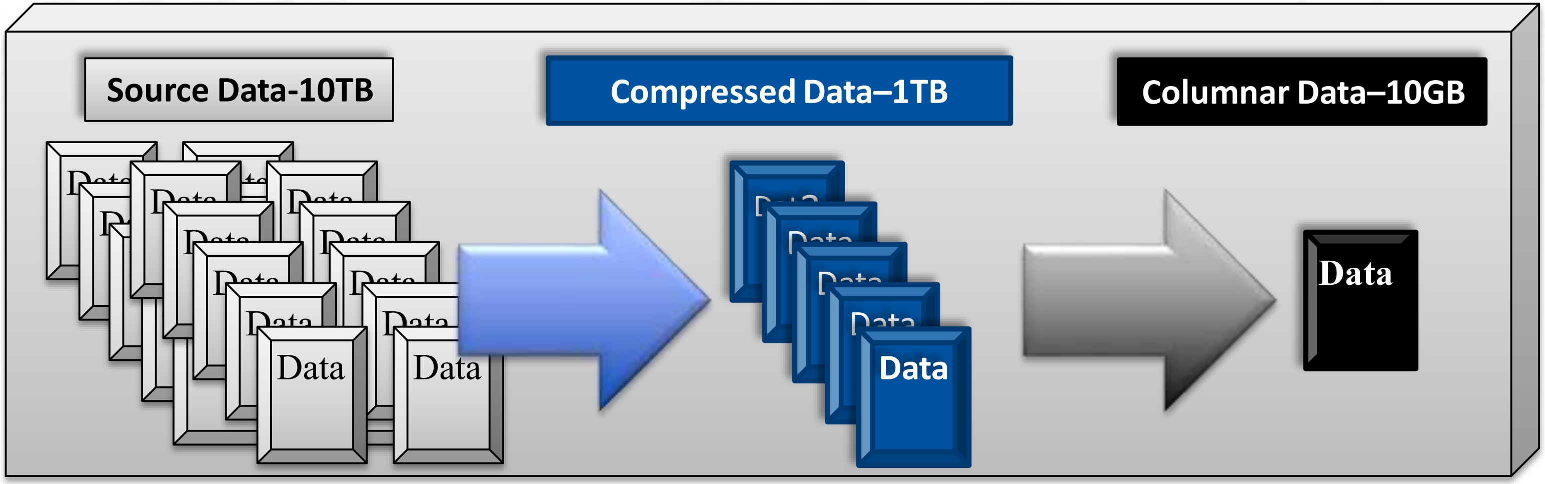
- Community is working on HDFS Snapshot capabilities
  - Maprfs – Amazon
    - Provides snapshots
  - Namenode single point
    - Dual nodes heartbeat sync
- Map Reduce Output(s)
  - Standard DR Backups
  - Transform to Archive
  - Standard reports/files



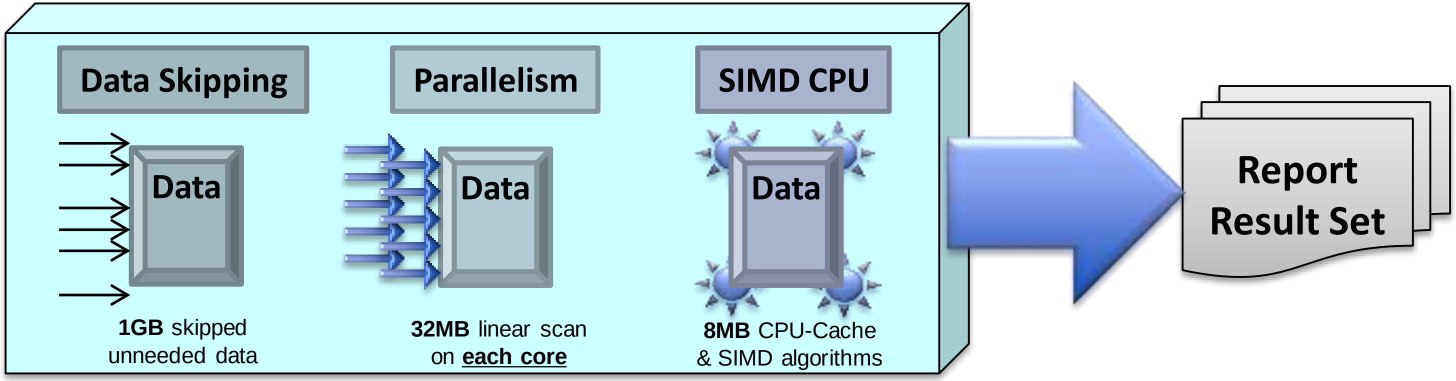
Best backup Hadoop:
Do only Config, Inputs, Outputs

Db2 BLU – Columnar Data Store

- 10TB to 10GB for data at rest
  - ***Extreme*** Compression
  - 1/1000th of the storage space

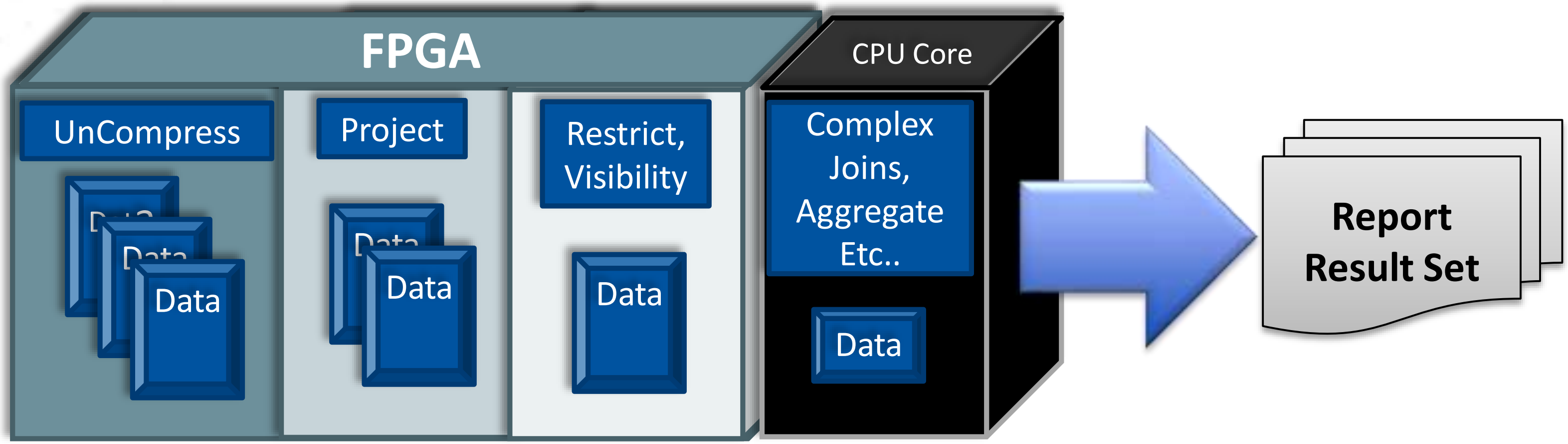


- Processing Data Set
  - Data Skip reduces I/O
  - Parallelism of 32MB linear scans
  - SIMD Cache operates on data


Data Skipping
Parallelism
SIMD CPU
Data
Data
Data
1GB skipped unneeded data
32MB linear scan on each core
8MB CPU-Cache & SIMD algorithms
Report Result Set

Db2 combined within IDAA

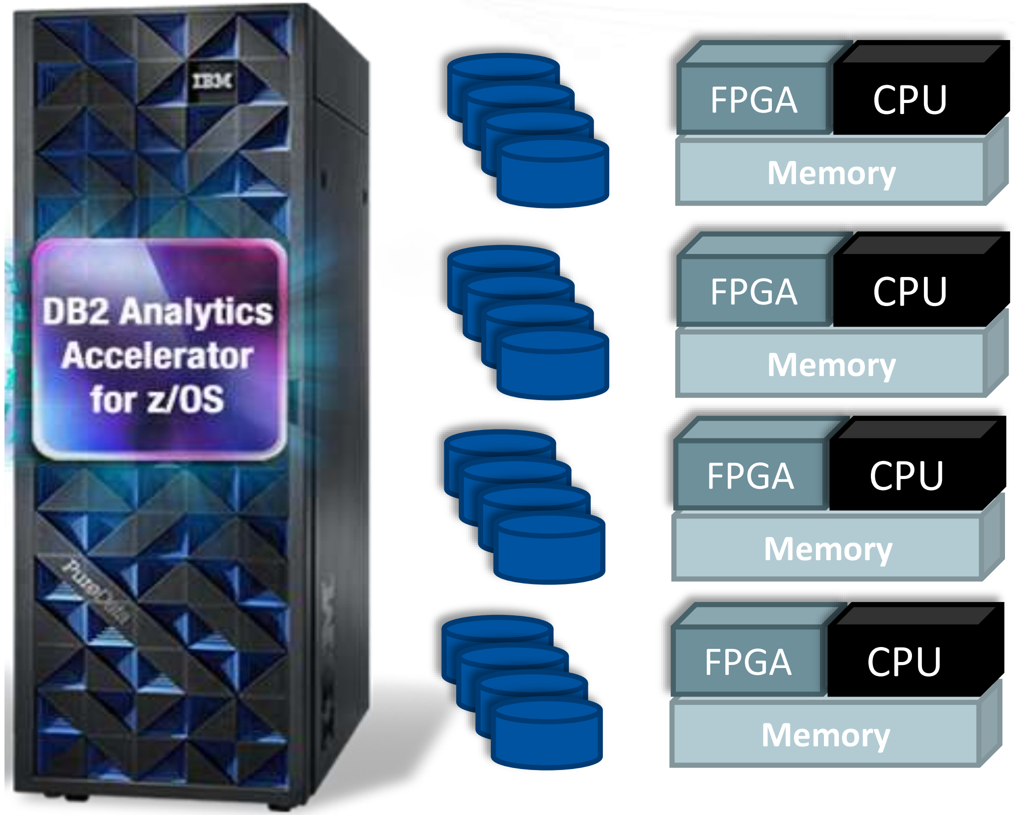
- Field Programmable Gate Architecture - FPGAs
- FPGA limits data before it gets to the CPU



```
SELECT CUST, ADDR, SUM(TXS)
FROM BEULKE.CUST1
WHERE CITY = ‘Malta’
AND SEGM = 9
```

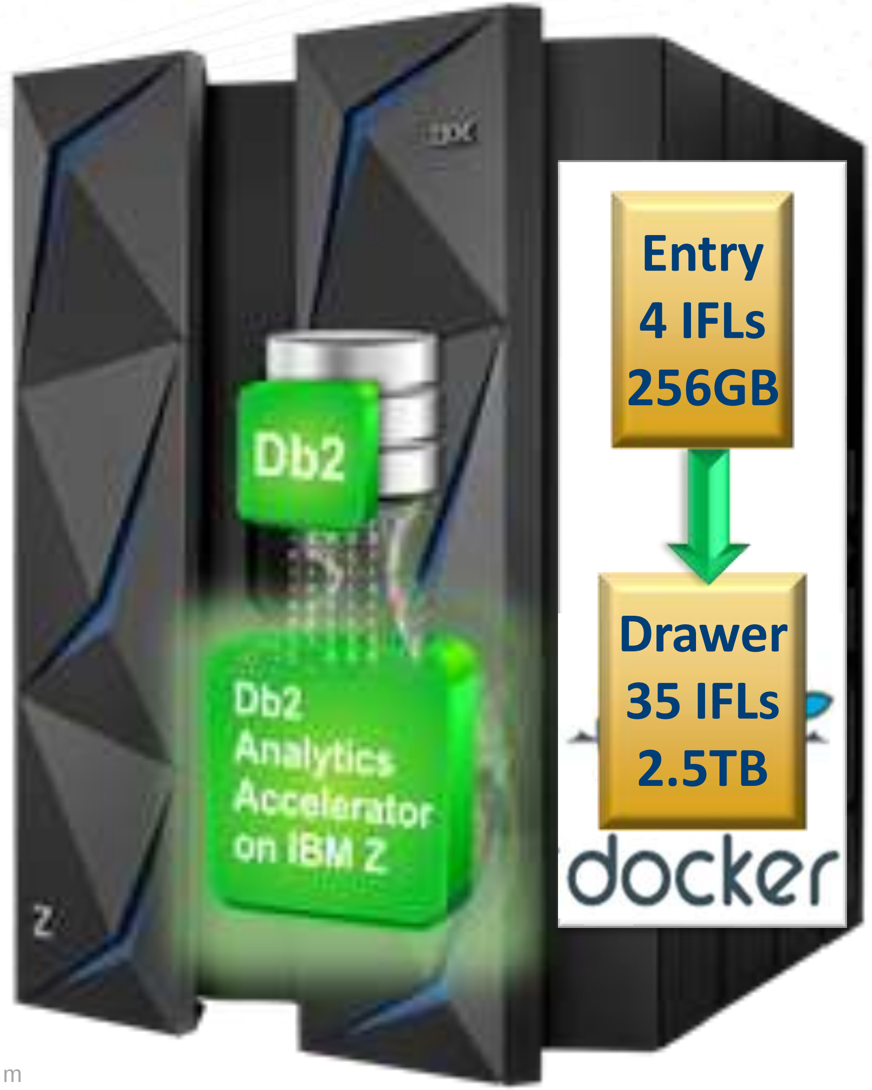
Db2 combined with IDAA

- Db2 routing SQL to IDAA
- Hardware Processing Speed
- Processing minimizes data
- Table level customization
- Great AOT options also
- DR is fast & easily resolved



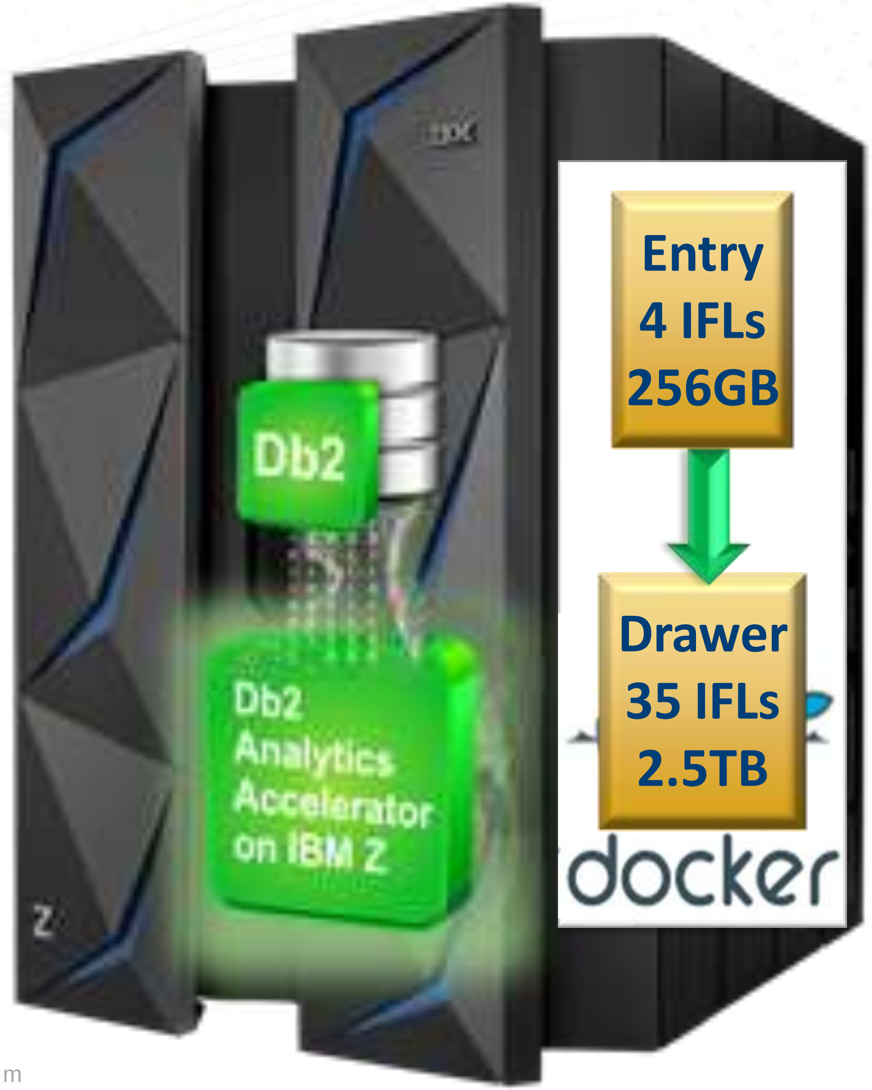
Best practices leverage the latest technology

- Accelerator runs native on z14
- Only on IBM z14 only within a Docker Container
  - not on z13, not on LinuxONE
- Uses the IBM Z Secure Service Container LPAR
- Need to make sure that *"Special Bid Pricing"* can include an Accelerator in your new z14



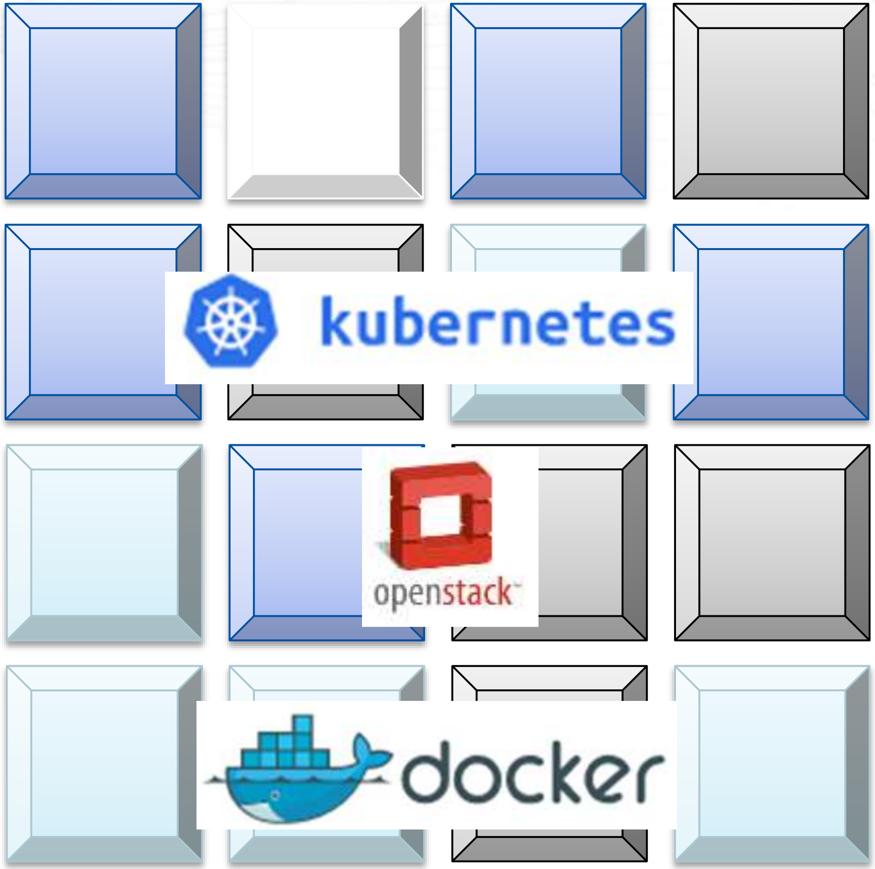
Accelerator on IBMz Docker LPAR

- Enhancement for IDAA
  - Further integration of HTAP features for Db2
  - Better within the large memory space of SystemZ
- Can be configured just like any IDAA
- Direction of IDAA
  - Same private network connections
- Provides growth path for Accelerator
- Make sure to order z14 with IDAA
  - Need to make sure that *"Special Bid Pricing"* can include an Accelerator in your new z14



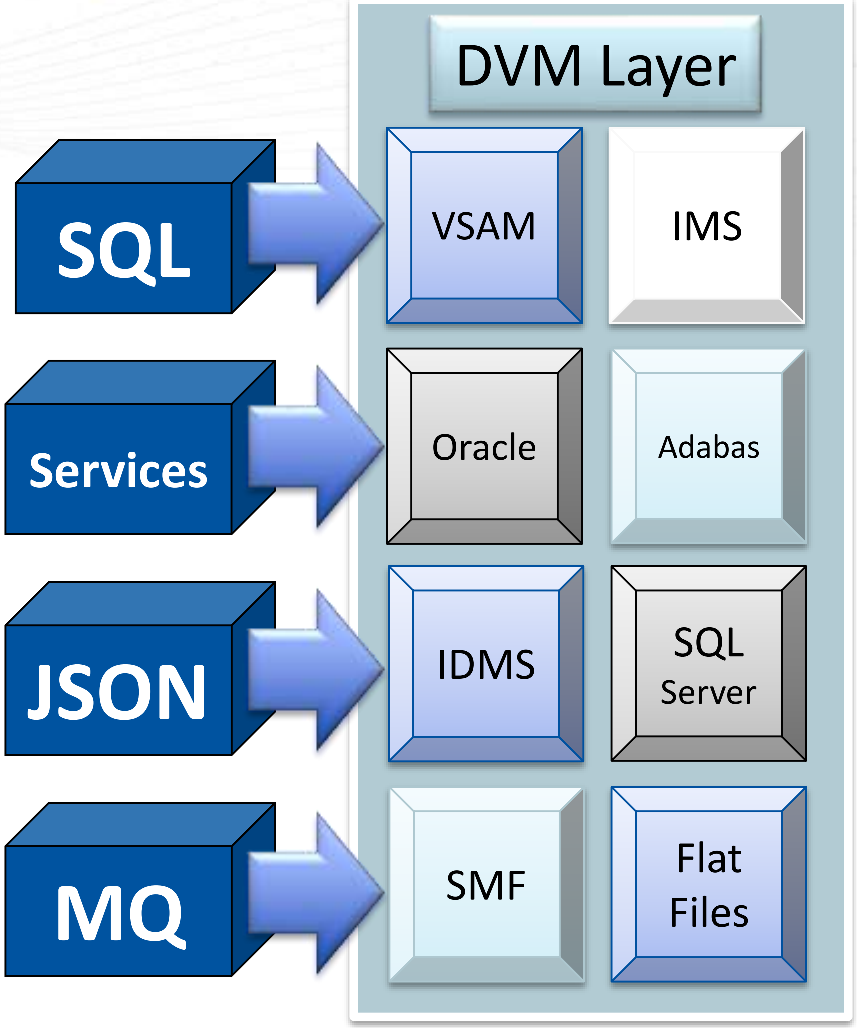
Data Grid, In memory or containers

- Cache Size
  - Cache expiration
  - Independent updates to the underlying data store
  - Synchronous or asynchronous updates
- Consistent Client view of your data
  - How to do scale up, replication and failover?
  - Which container provides best security/performance?
  - New OpenStack Kata, Docker or kubernetes?
- There is a huge complexity cost of cache/container management!



Data Virtual Manager - DVM

- ***Relational SQL access for any data store***
  - VSAM
  - IMS
  - IDMS
  - SMF or flat files
  - SQL Server
  - Oracle
  - Adabas
- Provides SQL, JSON & RESTful services interface
- MQGet/MQPut messages access virtual layer
- ***SQL JOINs with non-relational data stores!***



Best practice leverage Watson ML AI partner resources

- Automatic data relationship discovery
  - Automatically reviews and develops the relationships within the data
  - If you are subscribed to the Professional edition or the Plus edition of Watson

- Analytics, you have access to more types of data:
  - Cognos® BI reports
  - Databases such as IBM Db2®, IBM dashDB®, IBMSQL Database for Bluemix®,
  - Microsoft SQL Server, MySQL, Oracle, PostgreSQL

- Best practice: Determine the profits from questions and answers
- Free Db2 on cloud trial: **https://www.ibm.com/cloud/db2-on-cloud**

Any ML and AI types already used?

- What analysis type is best for your business problem/optimization?

Supervised Learning

- Using a given set of variables a function is generated that maps the inputs to the desired outputs executed until model achieves a desired level of accuracy

Unsupervised Learning

- Used for clustering population in different data groups which is widely used for segmenting customer in different groups for specific intervention
- No target or outcome variable to predict or estimate

Reinforced Learning

- Tries to capture the best possible knowledge acquired from past experience to make accurate business decisions
- The machine is trained to make specific decisions where it is exposed to an environment and makes the best possible decisions through trial and error.

- ML on Watson versus other data stores
  - Performance matters & Data Refresh time matters

ML initiatives mean different ideas within the same meeting

- Encounter skepticism and resistance to change when implementing AI and machine learning
- Which type of algorithm?
  - Reiterative Algorithms
  - What algorithm type & formula best?
  - What algorithms is the business use today?

- Identify patterns in systems
  - feedback loop so that previous recommendations are input to improve the next recommendations
- SQL **WHERE** Filters → train ML algorithms for desired outcome
  - **How big is your required sample size?**

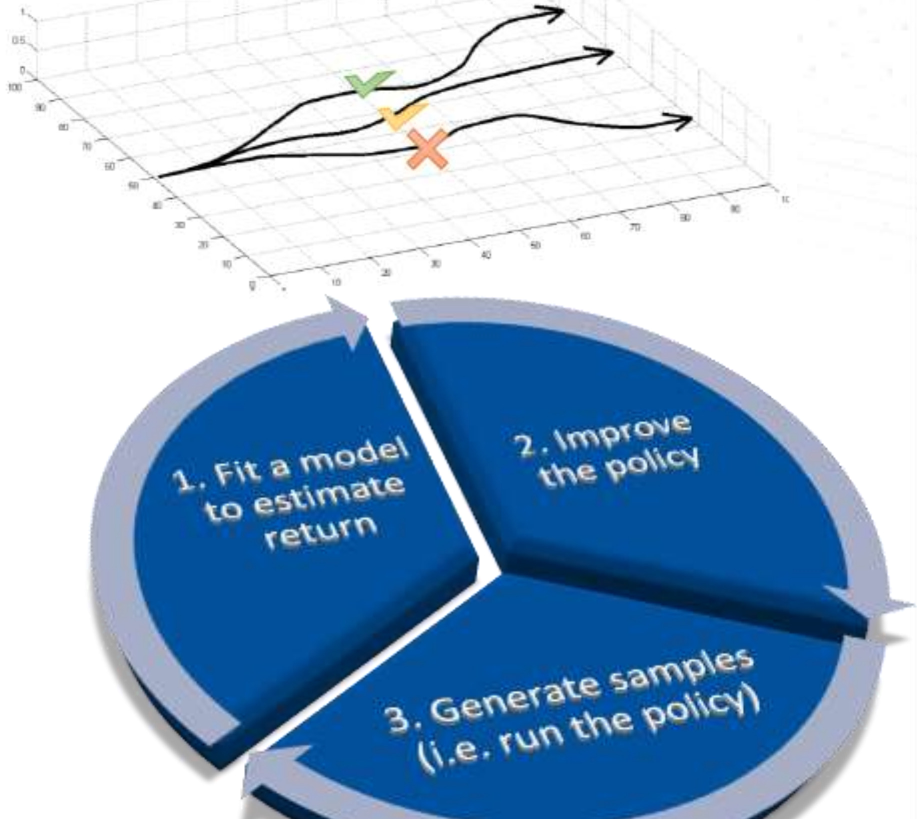
ML and AI Challenges

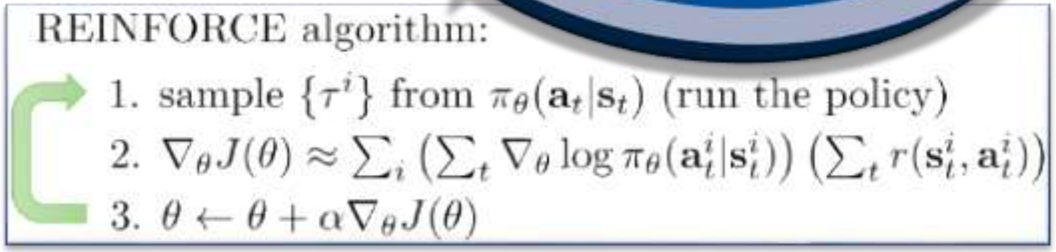
- Redesign the accountabilities and verify business is prepared to consume ML/AI conclusions

- Applying machine learning technologies, choose one with measurable results and economic effect

- You **can't** do analytics…
  - Without a good understanding of the data requirements
  - Without the best algorithm for the business situation
  - Without a solid high performance data infrastructure
  - AI without machine learning

- Machine learning systems can predict fraud and has gotten sophisticated enough to detect when behavior deviates


1. Fit a model to estimate return
2. Improve the policy
3. Generate samples (i.e. run the policy)

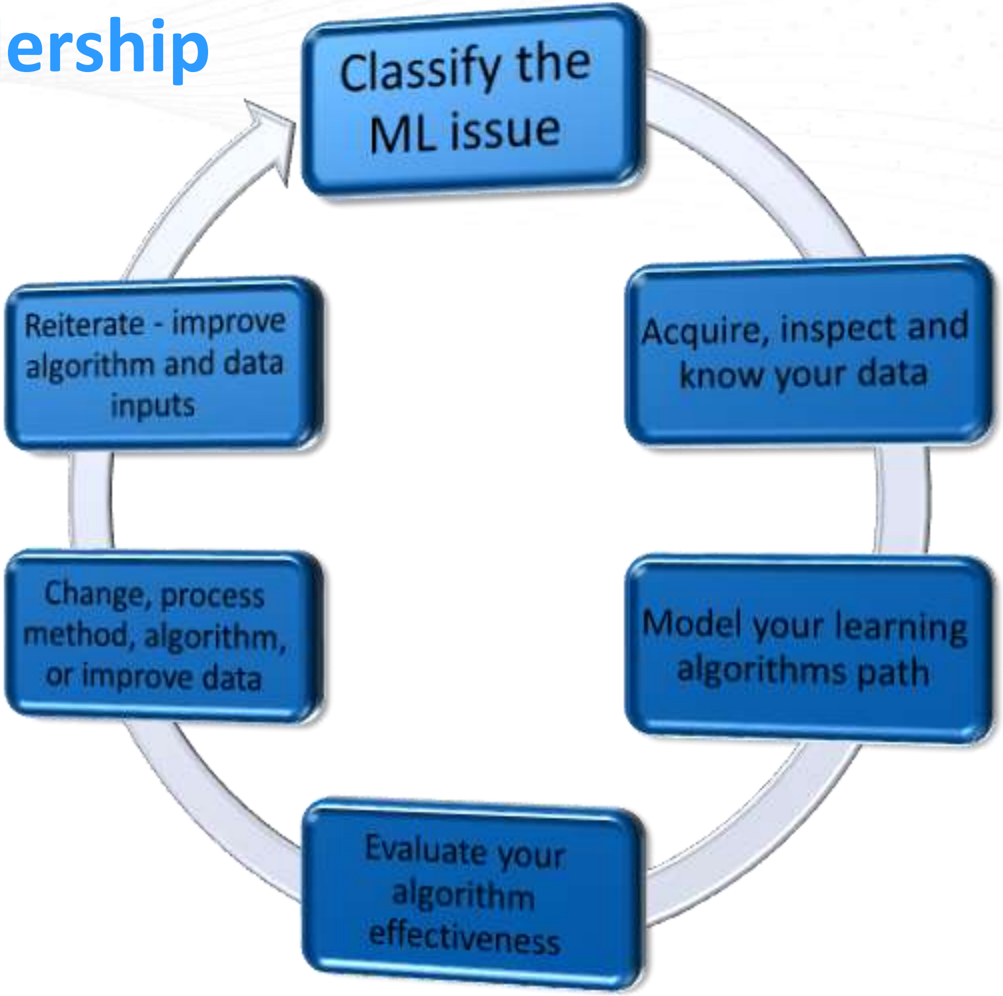


REINFORCE algorithm:

1. sample $\{\tau^i\}$ from $\pi_\theta(\mathbf{a}_t|\mathbf{s}_t)$ (run the policy)
2. $\nabla_\theta J(\theta) \approx \sum_i \left(\sum_t \nabla_\theta \log \pi_\theta(\mathbf{a}_t^i|\mathbf{s}_t^i)\right)\left(\sum_t r(\mathbf{s}_t^i, \mathbf{a}_t^i)\right)$
3. $\theta \leftarrow \theta + \alpha \nabla_\theta J(\theta)$

ML AI requires experienced leadership

- Business challenge to ML
- Exploring or Predicting
  - Knowledge or Speculation?
- ML Leaning will based off what?
  - Fraud detection processing
  - Bank Loan examination
- Data discovery within new data
  - New data classification discovery
  - Is your ML able to predict?



Classify the ML issue

Acquire, inspect and know your data

Model your learning algorithms path

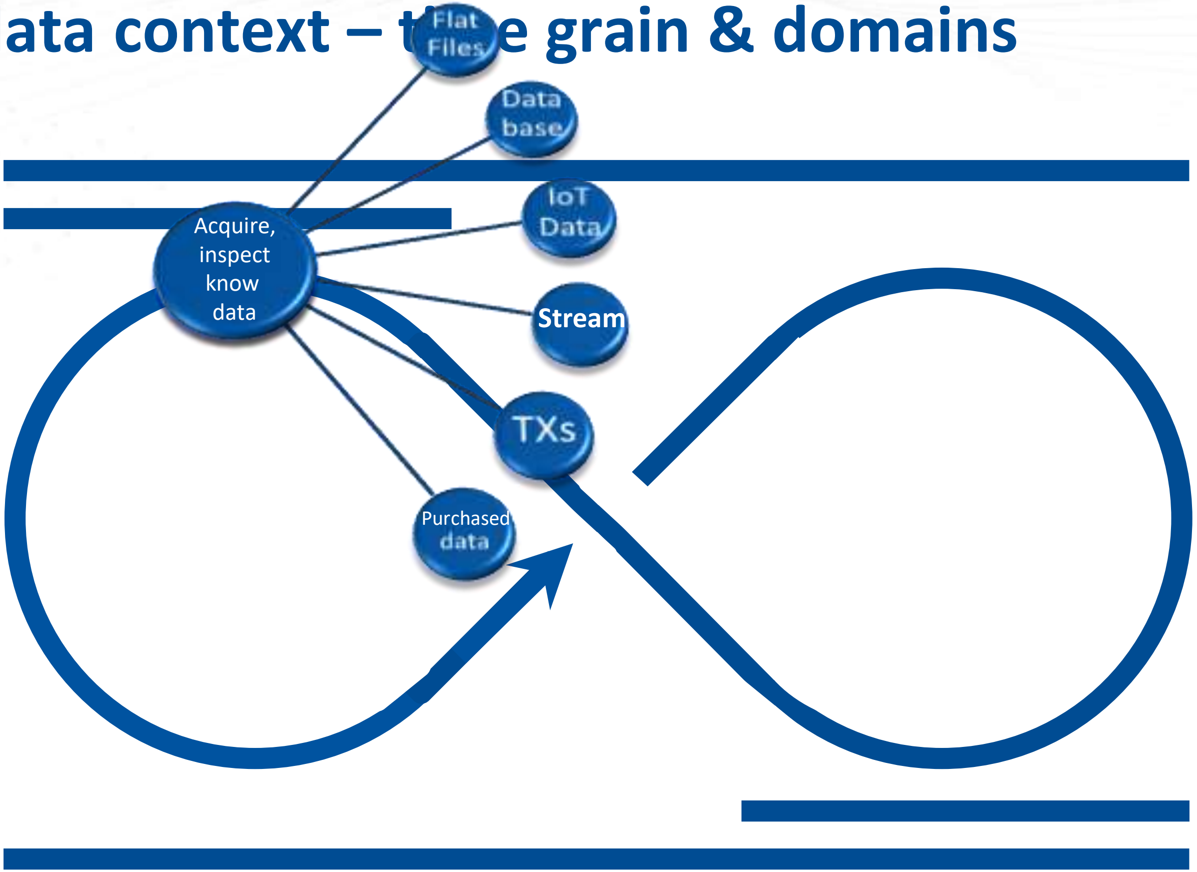
Evaluate your algorithm effectiveness

Change, process method, algorithm, or improve data

Reiterate - improve algorithm and data inputs

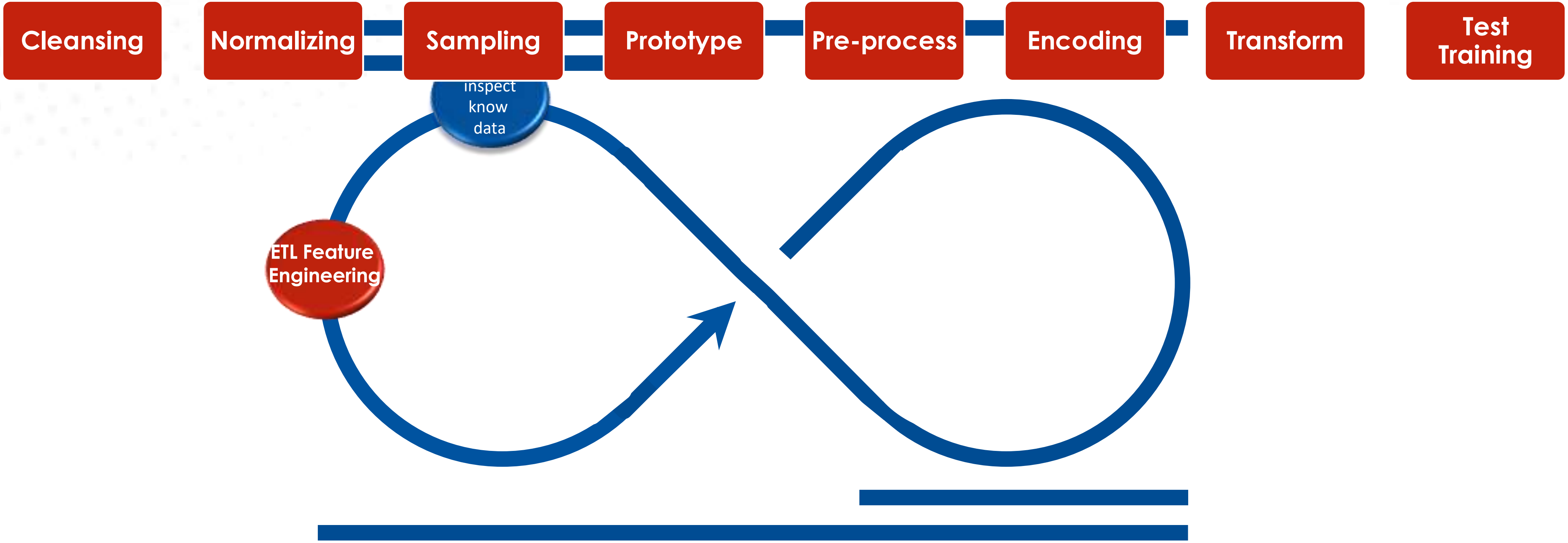
ML & AI Complex Ecosystems

- Know the data context – the grain & domains



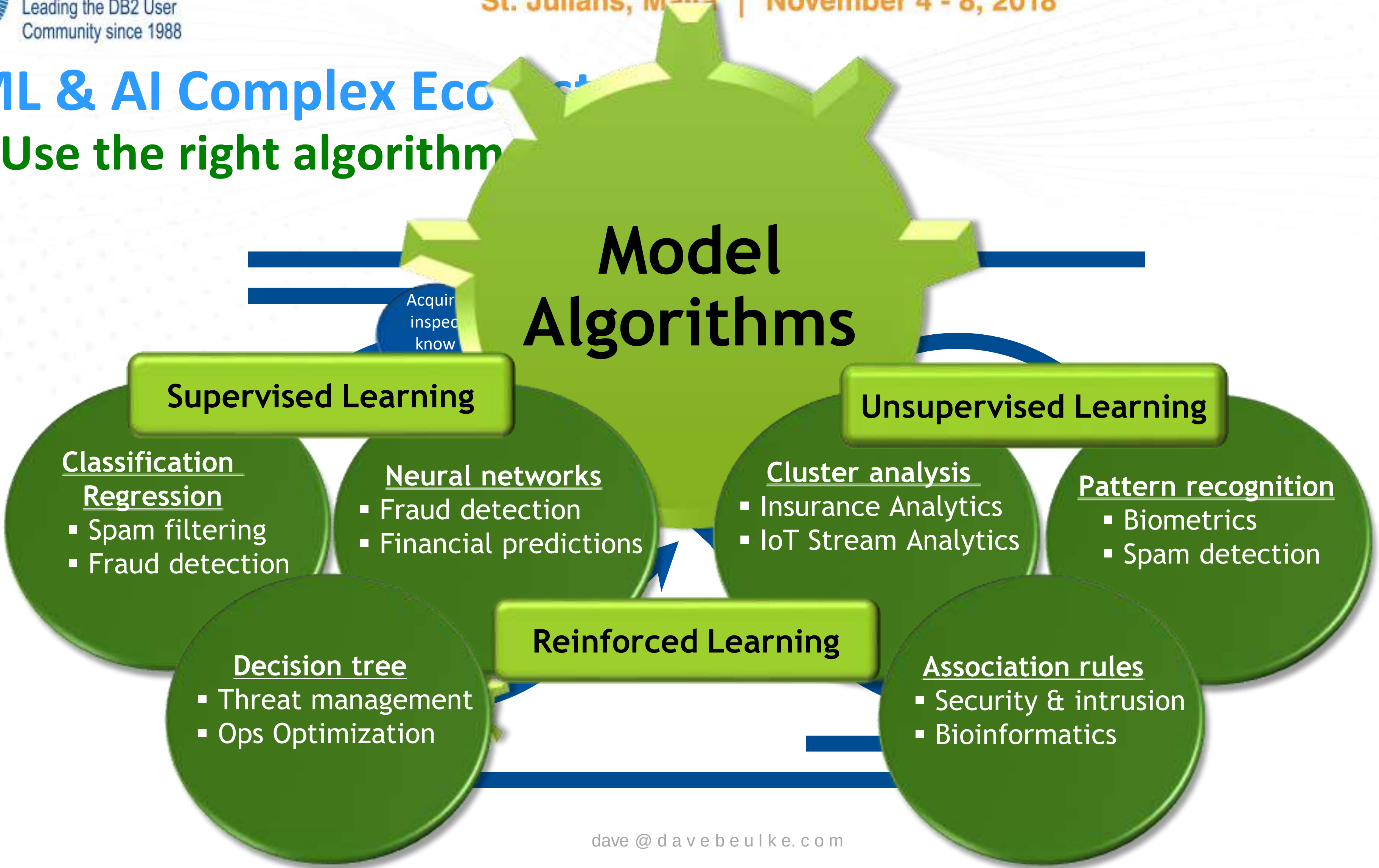
ML & AI Complex Ecosystems

- Preparing the data



ML & AI Complex Eco

- Use the right algorithm



ML & AI Complex Ec

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NEURAL NETWORKS

$$f(x) = o = w_0 + \sum_{i=1}^{n} w_i x_i$$

SIMILARITY

$$w_{ij} = \frac{\sum_k (R_{ix} - \bar{R}_i).(R_{jk} - \bar{R}_j)}{\sqrt{\sum_k (R_{ix} - \bar{R}_i)^2 . (R_{jk} - \bar{R}_j)^2}}$$

DECISION TREE

$$Entropy = \sum_{v=0}^{1} -P.\log$$

$$InfoGain = P_+.\left[-P_{+t}.\log(P_{+t}) - P_{+(t-1)}-.\log\left(P_{+(t-1)}\right)\right]$$

Which is the best algorithm for the business situation?

- Linear Regression
- Logistic Regression
- Decision Tree
- SVM
- Naive Bayes
- kNN
- K-Means
- Random Forest
- Dimensionality Reduction
- Gradient Boosting algorithms

……and hundreds more ……

AXIMUM LIKELIHOOD

$$_L = \arg\max P(c|a)$$

TOTAL PROBABILITY

$$TotalP(B) = P(B|A).P(A)$$

VARIANCE

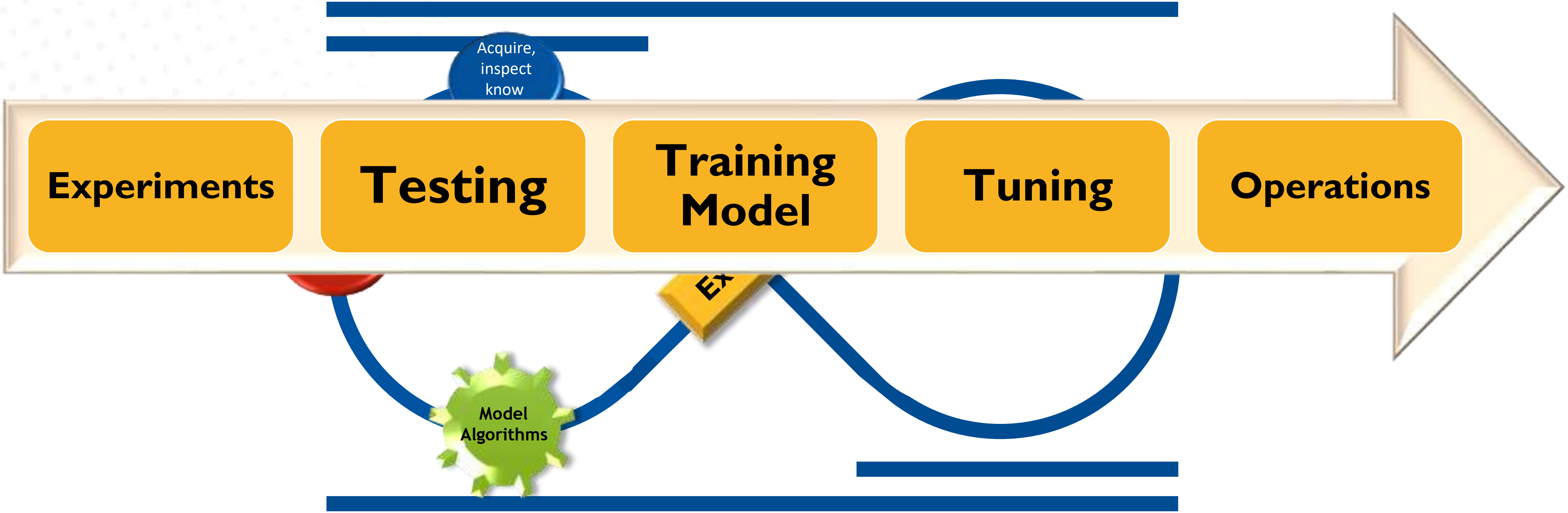
$$= \frac{\sum (x - \bar{x})^2}{n - 1}$$

RESSION

$$m_1 = \frac{\sum x_2^2 \sum x_1 y - \sum x_1 x_2 \sum x_2 y}{\sum x_1^2 \sum x_2^2 - (\sum x_1 x_2)^2}$$

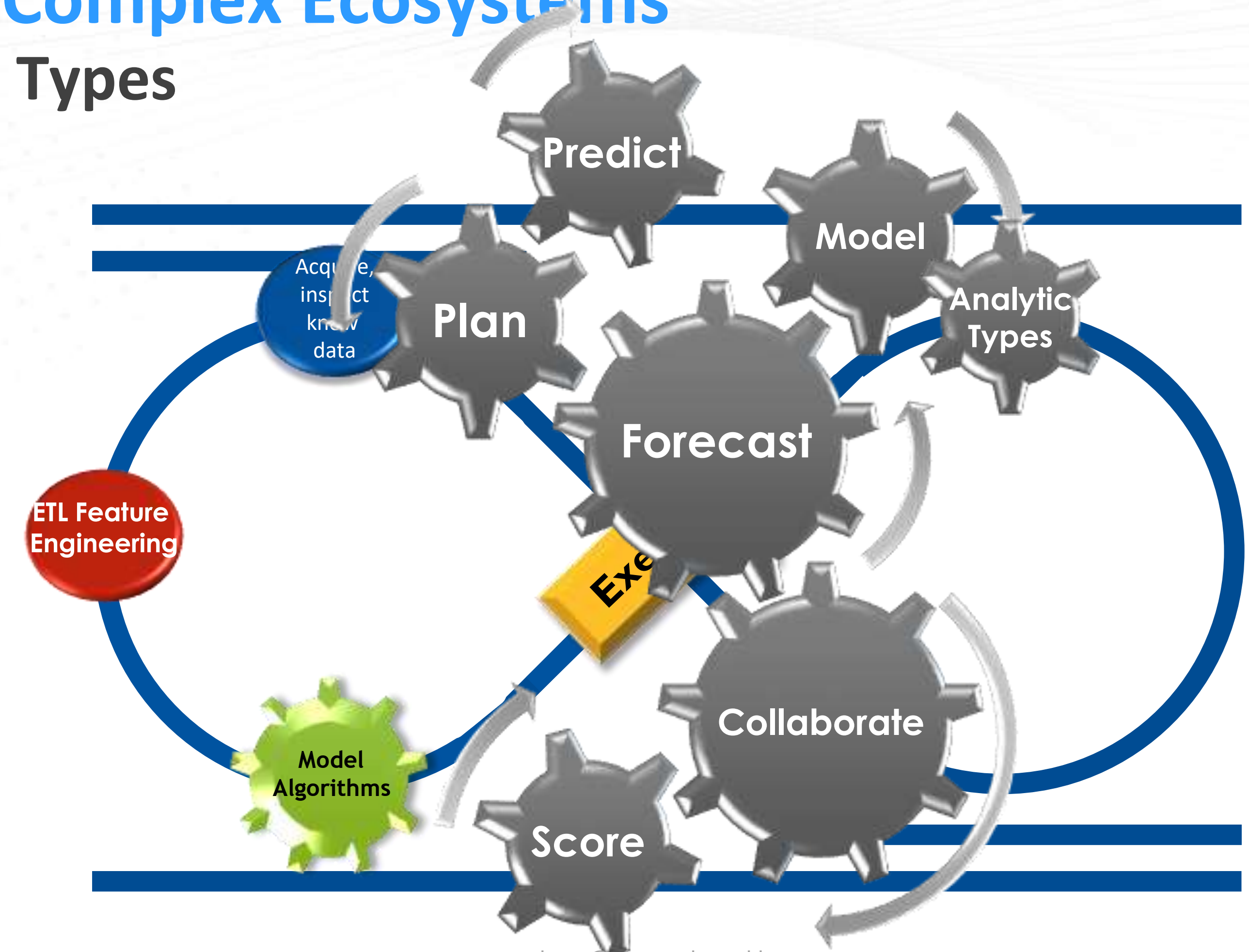
ML & AI Complex Ecosystems

- Execution & Operations



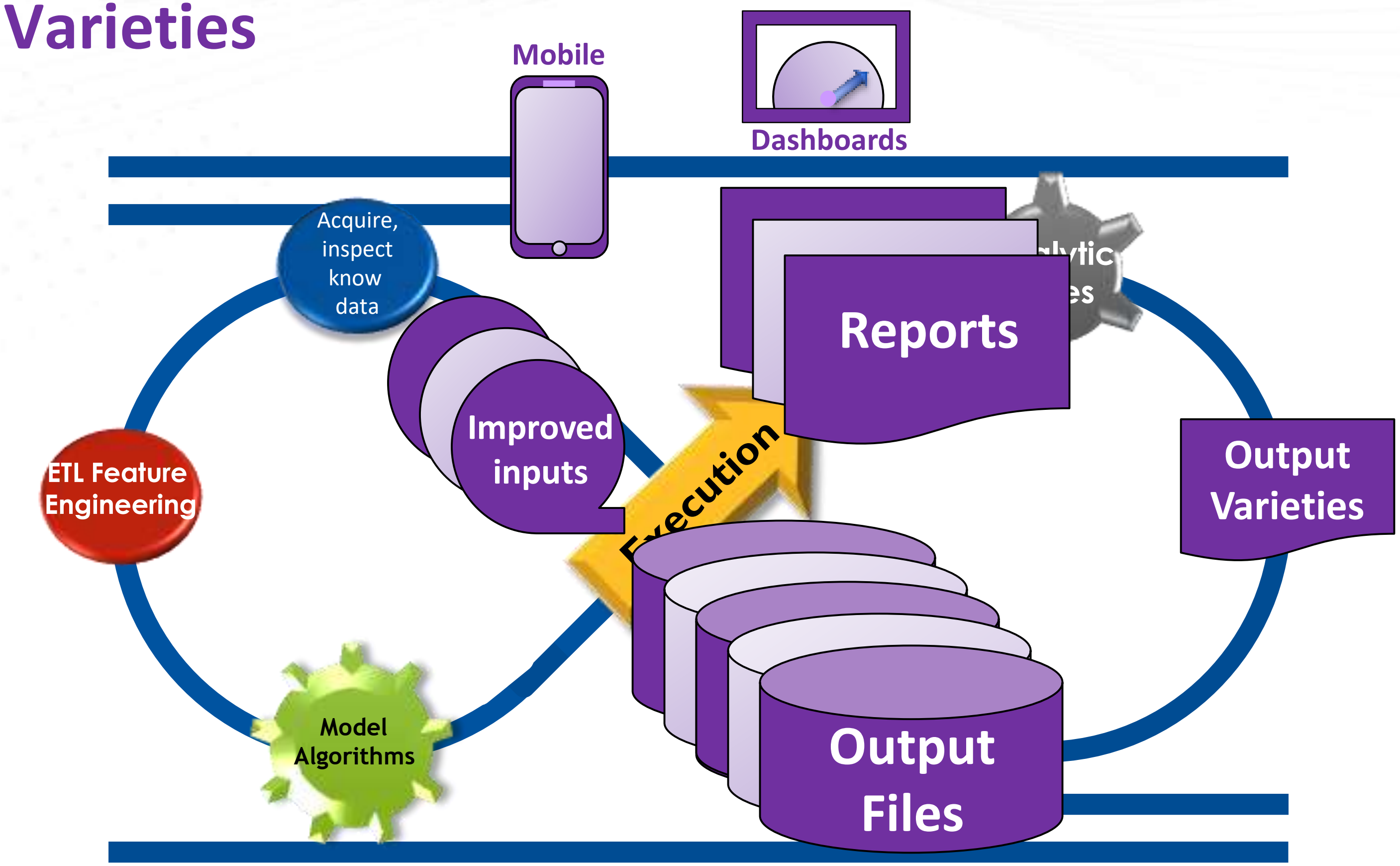
ML & AI Complex Ecosystems

- Analytic Types



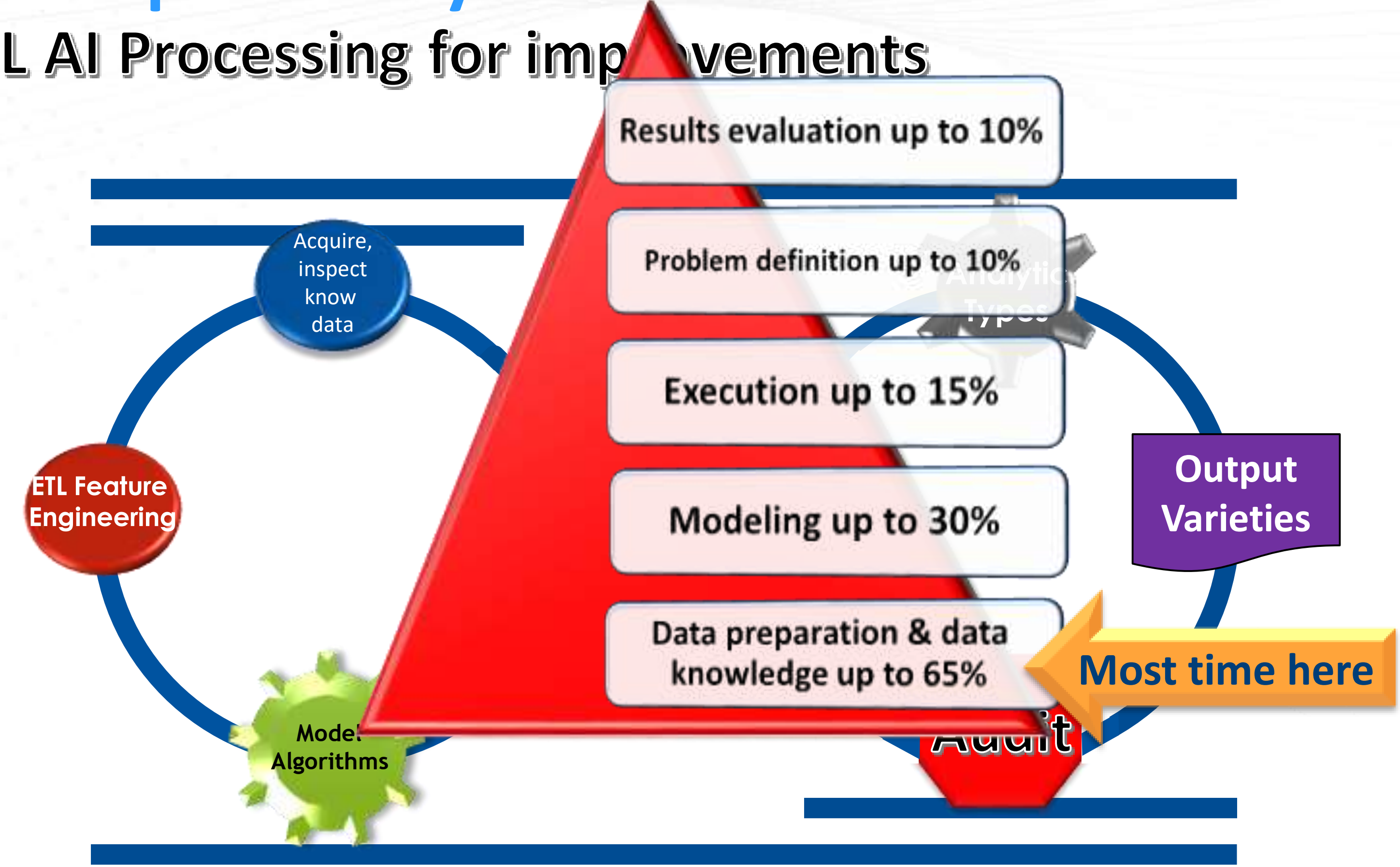
ML & AI Complex Ecosystems

- Output Varieties



ML & AI Complex Ecosystems

- Audit ML AI Processing for improvements



Results evaluation up to 10%

Problem definition up to 10%

Execution up to 15%

Modeling up to 30%

Data preparation & data knowledge up to 65%

Most time here

Acquire, inspect know data

ETL Feature Engineering

Model Algorithms

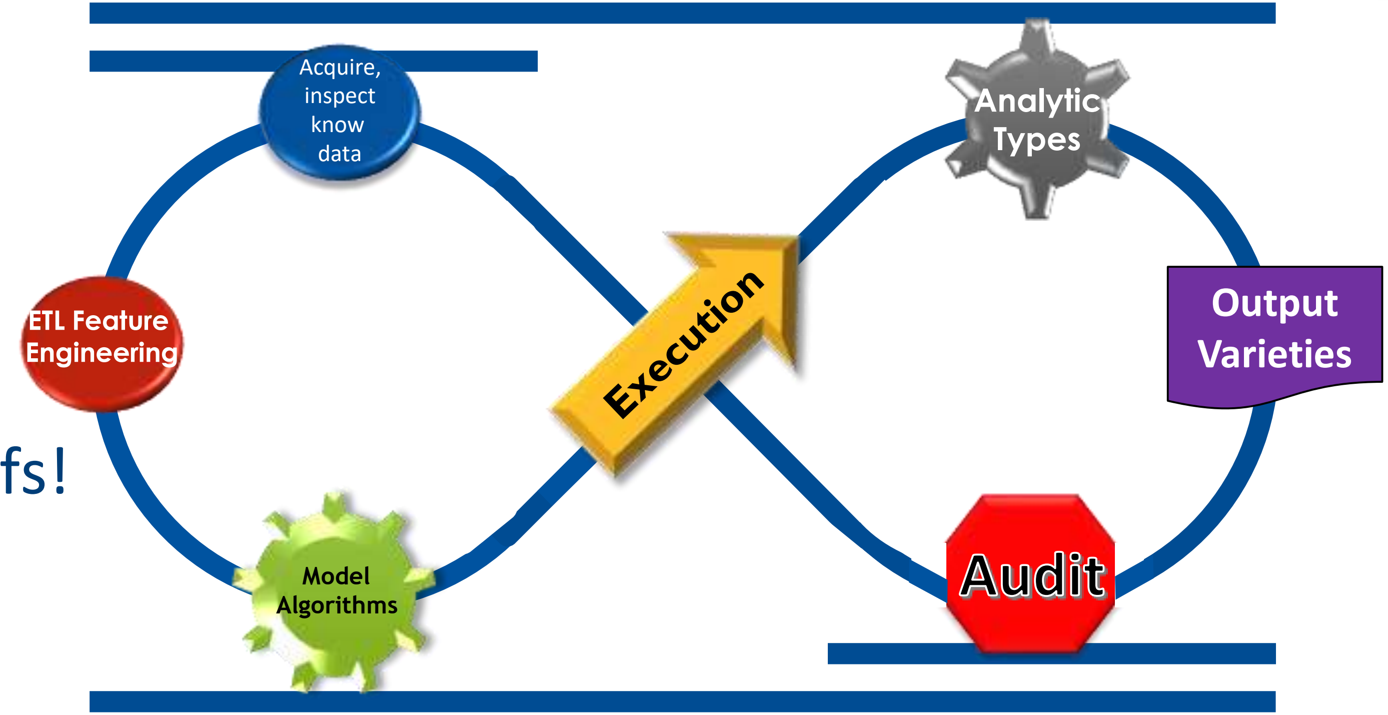
Analytic Types

Output Varieties

Audit

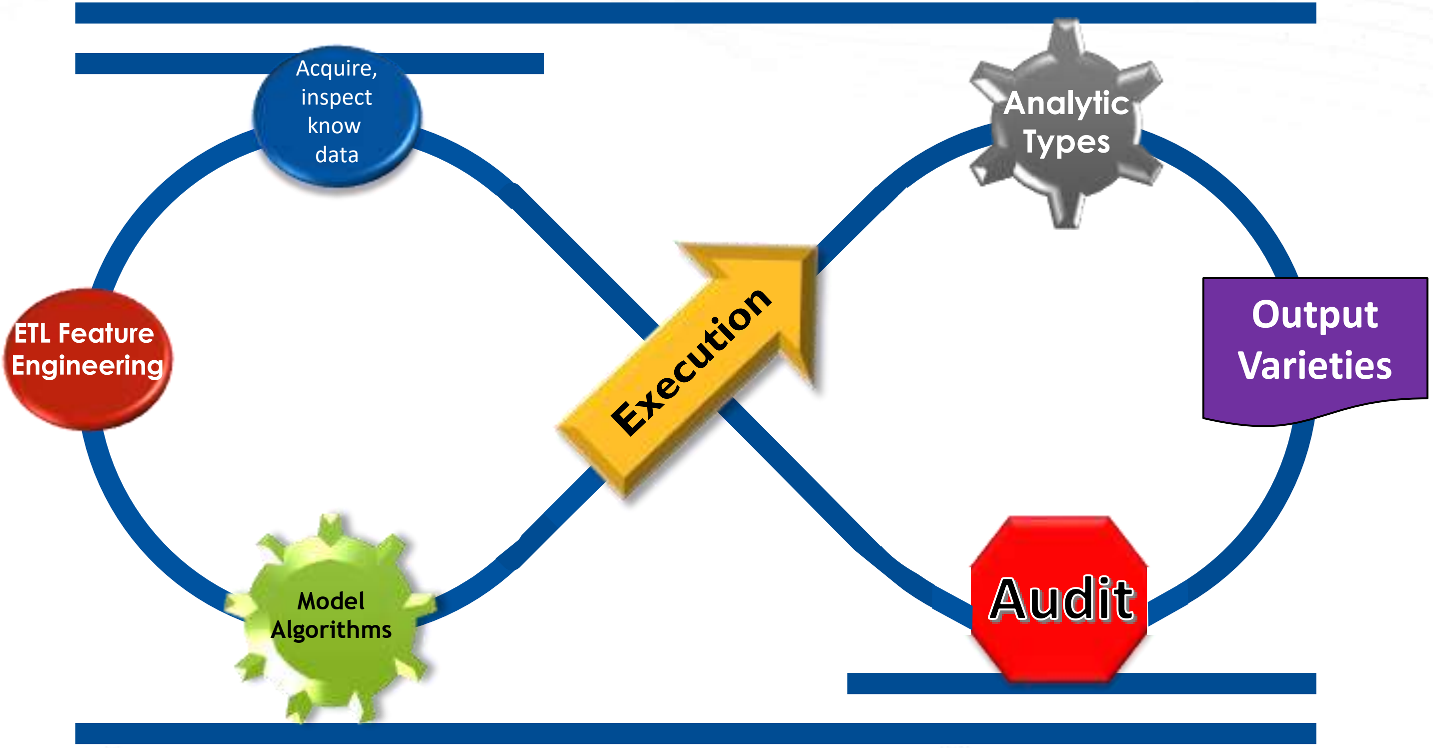
ML & AI Complex Ecosystems

- Research, run and repeat
  - ***Add ML or AI to any project proposal and it will be approved***
- Inflection point
  - Market share competition
  - Operational optimization
  - Grow market differentiators
  - Eliminate fraud
- Long term, big payoffs!



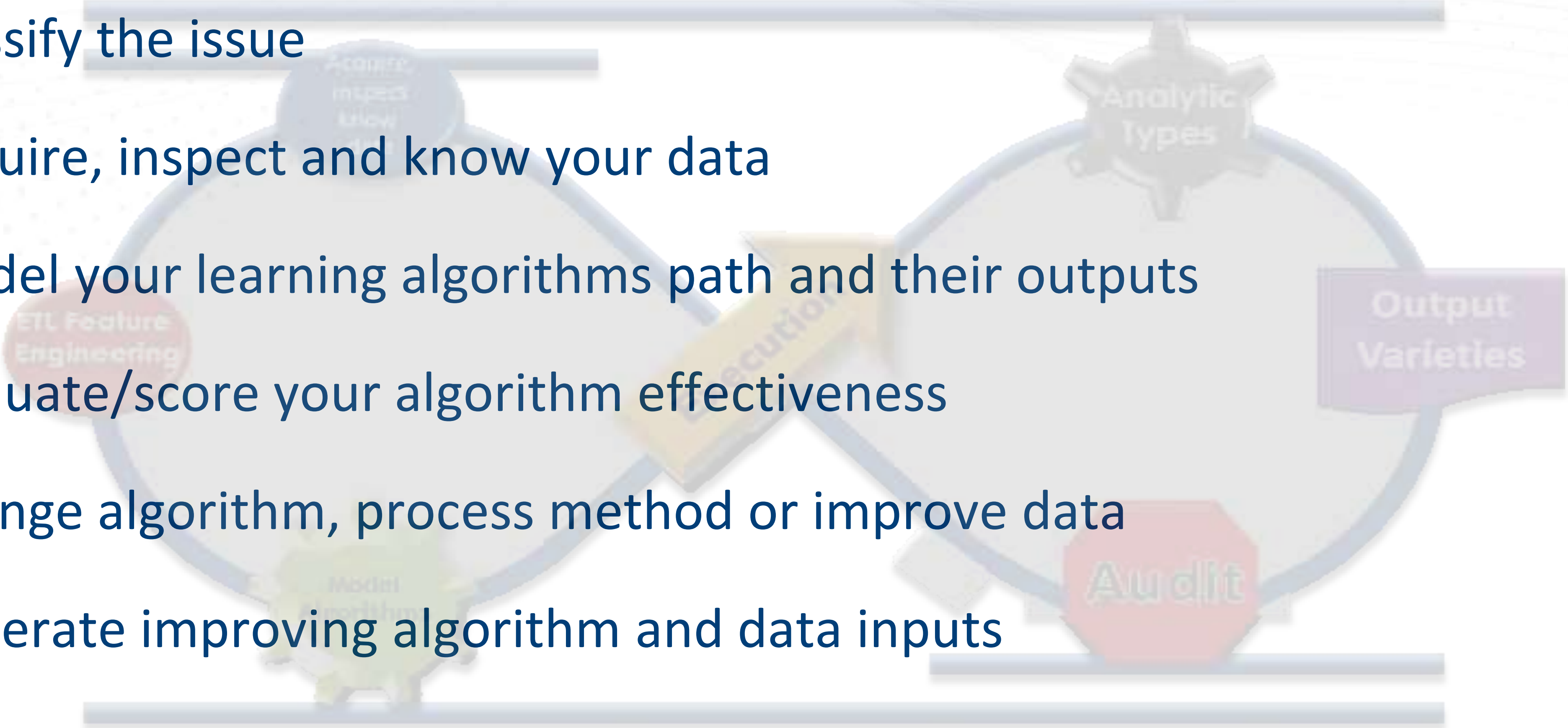
Best practice simplify complexities

- More computing power needed for every aspect
  - Any single phase can impact all the other components within your ML or AI project
  - Each phase should have its SME to optimize its planning, testing and performance
  - Understand self improving formulas in C#, Python or R
  - Develop prototype and test your formulas that demonstrate ***ROI***



$$Q(s_t,a_t) \leftarrow \underbrace{Q(s_t,a_t)}_{\text{old value}} + \underbrace{\alpha}_{\text{learning rate}} \cdot \left(\overbrace{\underbrace{r_t}_{\text{reward}} + \underbrace{\gamma}_{\text{discount factor}} \cdot \underbrace{\max_a Q(s_{t+1},a)}_{\text{estimate of optimal future value}}}^{\text{learned value}} - \underbrace{Q(s_t,a_t)}_{\text{old value}} \right)$$

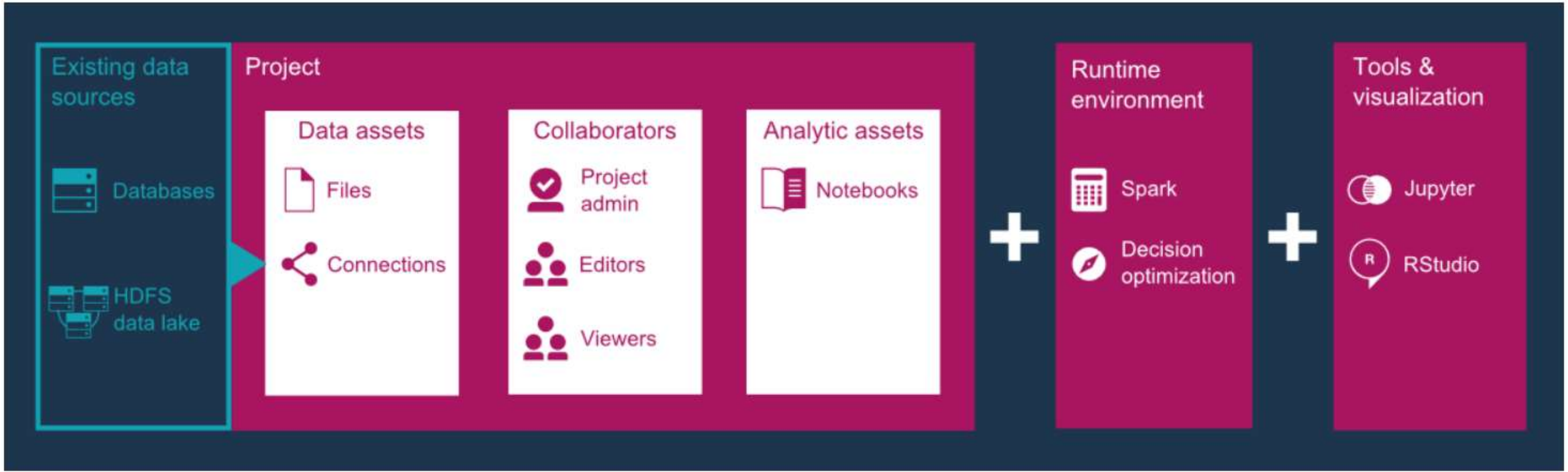
ML AI leverage DW performing continuous experiments



- Classify the issue
- Acquire, inspect and know your data
- Model your learning algorithms path and their outputs
- Evaluate/score your algorithm effectiveness
- Change algorithm, process method or improve data
- Reiterate improving algorithm and data inputs

IBM Data Science Experience - DSX

- IBM 3 types of DSX – Cloud, Local or Hybrid
- DSX – Platform agnostic product interface for implementing your DS model
  - Runs on any platform with any type of server, data or languages



IBM Data Science Experience - DSX

- IBM 3 types of DSX – Cloud, Local or Hybird
- DSX – Platform agnostic product interface for implementing your DS model
  - Runs on any platform with almost any type of server, un/structured data or programming languages

Cloud DSX

https://www.ibm.com/cloud/get-started

Project
Data assets
Files
Connections
Collaborators
Project admin
Editors
Viewers
Analytic assets
Notebooks
+
Runtime environment
Spark
Decision optimization
+
Tools & visualization
Jupyter
RStudio

Data Science made simple with IBM DSX |
by Krishna Chaitanya

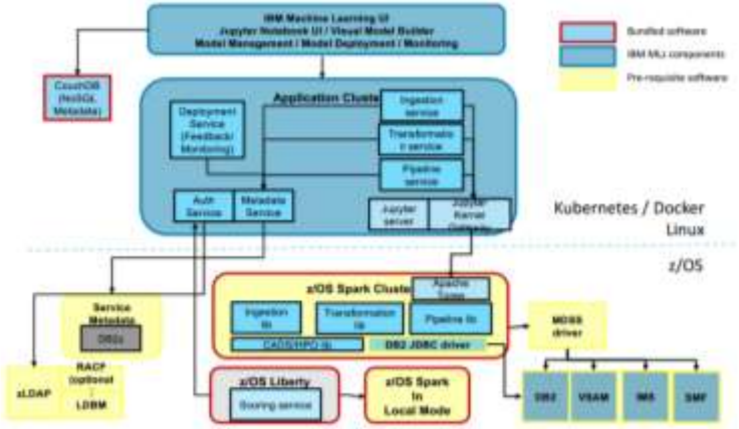
Local DSX

x86 Servers

IBM Power

System z

DSX ML on z



Many factors for Analytic Performance

- Storage efficiency/data amount vs. cos
- Private to Public inf
- I
- S
- Pro g CPU
- Reco ty

All the architectures work!

Db2 Family and IDAA have the best attributes and fits any processing situation!

Best Performance and Design Practices for Analytic Applications

By Dave Beulke
Dave Beulke and Associates
Dave @ davebeulke .com

Session code: **E1**

Proven Performance Tips:
www.DaveBeulke.com

Thank you!

Please fill out your session evaluation before leaving!

More ML and AI information

- **The best Machine Learning Resources**
  https://medium.com/machine-learning-for-humans/how-to-learn-machine-learning-24d53bb64aa1
- **Preparing and Architecting for Machine Learning - Gartner Inc.**
  https://www.gartner.com/binaries/content/assets/events/keywords/catalyst/catus8/preparing_and_architecting_for_machine_learning.pdf
- **Three Real Use-Cases of Machine Learning in Business Applications**
  https://www.huffingtonpost.com/entry/three-real-use-cases-of-machine-learning-in-business_us_593a0e91e4b014ae8c69df37
- **Smart Implementation of Machine Learning and AI in Data Analysis**
  https://callminer.com/blog/smart-implementation-machine-learning-ai-data-analysis-50-examples-use-cases-insights-leveraging-ai-ml-data-analytics/
- **140 Machine Learning Formulas**
  https://www.datasciencecentral.com/profiles/blogs/140-machine-learning-formulas
- **10 Algorithms Machine Learning Engineers Need to Know**
  https://www.simplilearn.com/10-algorithms-machine-learning-engineers-need-to-know-article
- **Hybrid Cloud with IBM Cloud Manager with OpenStack on z Systems**
  https://www-01.ibm.com/events/wwe/grp/grp019.nsf/vLookupPDFs/2_2_2_Heimes/$file/2_2_2_Heimes.pdf
- **NIST Definition of Cloud Computing**
  https://csrc.nist.gov/publications/detail/sp/800-145/final
- **IBM Integration Bus – MQ Version 9.04 download**
  http://ibm.biz/MQ_V9_FAQ & https://www-01.ibm.com/support/docview.wss?uid=swg24043348
- **Machine learning algorithm cheat sheet**
  https://docs.microsoft.com/en-us/azure/machine-learning/studio/algorithm-cheat-sheet

More ML and AI information

- **Azure Machine Learning first impressions**
  https://medium.com/@markryan_69718/azure-machine-learning-first-impressions-f7c8366b4971
- **Machine Learning for Humans**
  https://medium.com/machine-learning-for-humans/why-machine-learning-matters-6164faf1df12
- **Three Real Use-Cases of Machine Learning in Business Applications**
  https://www.huffingtonpost.com/entry/three-real-use-cases-of-machine-learning-in-business_us_593a0e91e4b014ae8c69df37