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Network-Enabled Artificial Intelligence (AI)

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Current Status of AI Work

ATIS published *Evolution to an Artificial Intelligence Enabled Network* in September 2018:

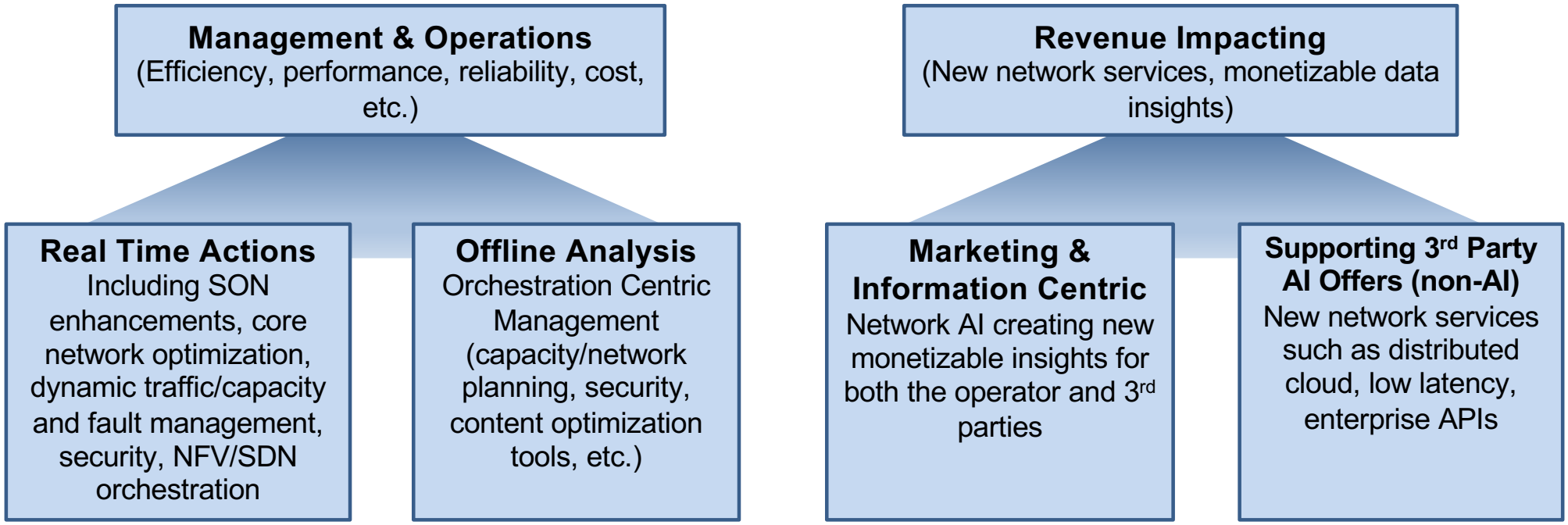
- Technology overview for network deployments
- Network use cases
- AI architectures and technologies for network deployments
- Network requirements in support of AI

Work has also been done on AI as applied to 5G; 5G use cases include:

- Management of dense mmWave 5G deployments with carrier aggregation and adjacent small-cell and macro overlays can present complex new challenges
- 5G network security enhancements: SPAM/DDoS detection/mitigation, improved identity management
- Core network optimization
- Network reliability with automated fault management and self-healing
- Optimized user experience using 5G

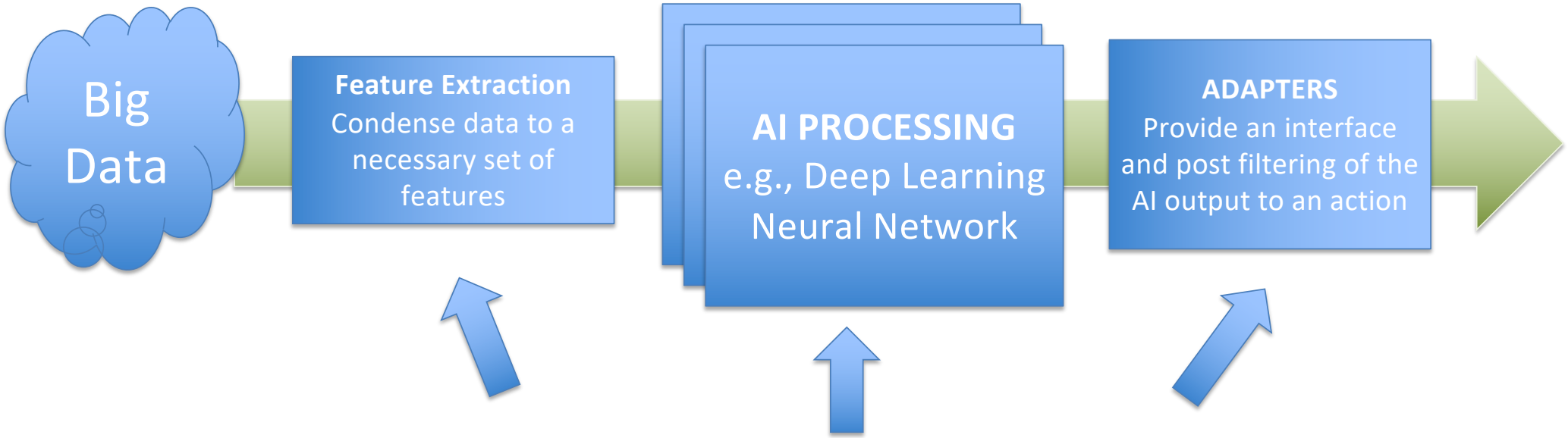
Artificial Intelligence (AI) provides the opportunity to automate and optimize all facets of the network.

AI: Network Impacted Areas



Common AI platforms to enable shared learning within the operator community.

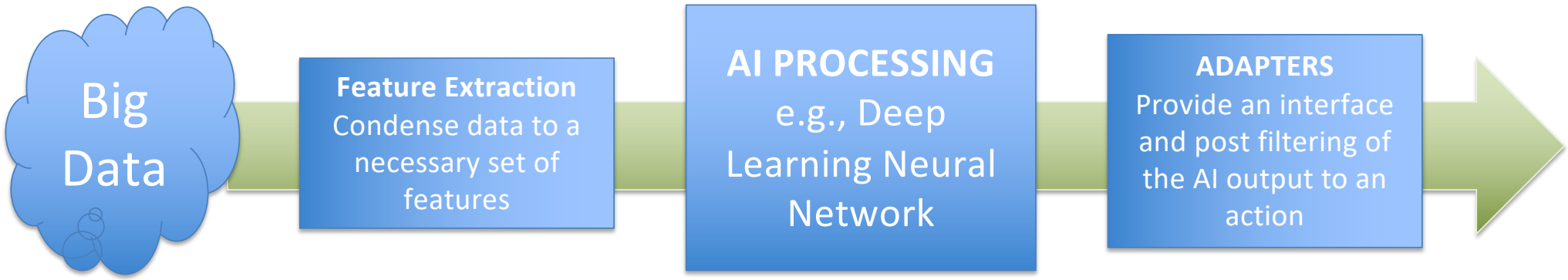
AI System/Subsystem as an AI Hierarchy



Distributed AI processing allows for better visibility and understanding of the results:

- AI modules could be used for more intelligent data feature extraction
- Main AI processing could be separated by AI Application
- Adaptors could use AI modules to better control the network (e.g., AI driven NFV) orchestration to dynamically adjust network services

Example of an AI System/Subsystem



KEY FACTORS:

- Data Exposure–Getting the right data in the right timeframe
- Extracting the right features
- Dealing with history and time dependency

KEY FACTORS:

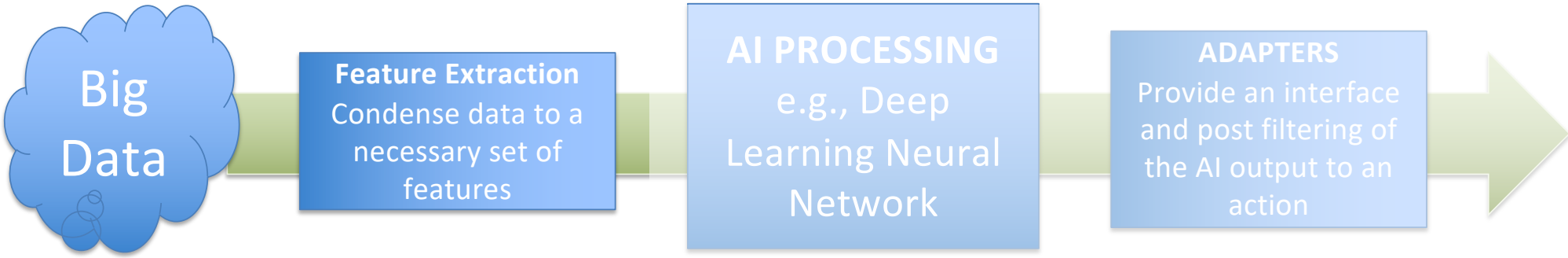
- Choosing a framework and library–Use of Open Source
- Creating a learning model
- Training data sets-Supervised and unsupervised/continuous learning environments

KEY FACTORS:

- Availability of APIs for proper control or display
- Potential application of rules based limits to deal with errors

Complex AI Systems are comprised of a network data source, AI processing and output adapters to utilize the results.

Data Collection/Extraction – AI System/Subsystem



DIMENSIONS of DATA:

Traffic characteristics/user behavior:

- Throughput, packet loss, latency, packet length (short or long), burstiness,
- As a function of application class and app specific metrics
- And subscriber class based on a set of application classes (SLAs, etc.)

Network/Subscriber State:

- 5G Control Plane metrics, transaction rates, infrastructure performance metrics

Topology/Location

- UE location–Even "fixed" assets may change with SDN / NFV

History/Time

- Busy hour/day of week/day of month/year

DATA COLLECTION:

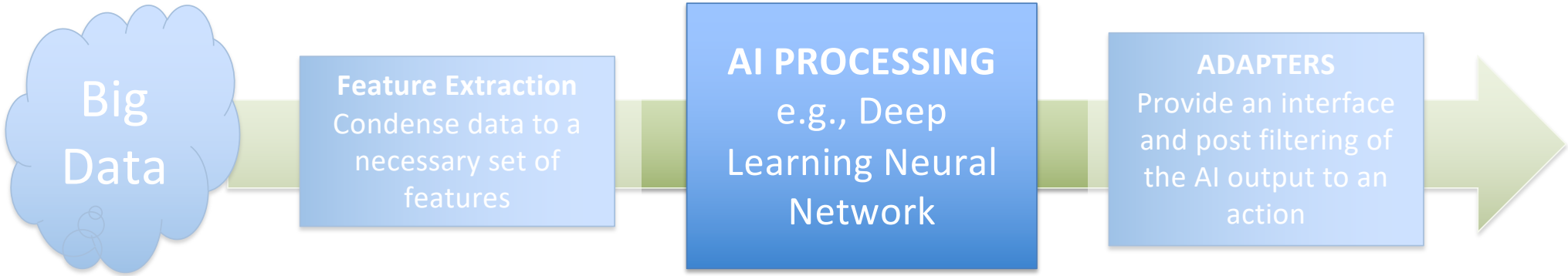
- Traditional methods, log files, etc.
- Instantiate virtual probes
- 3GPP–Network Data Analytics Function (NWDAF) (NEW)

FEATURE EXTRACTION

- Coded Algorithms
- AI based Analysis

Leverage network capabilities to collect the right data to match the desired analysis.

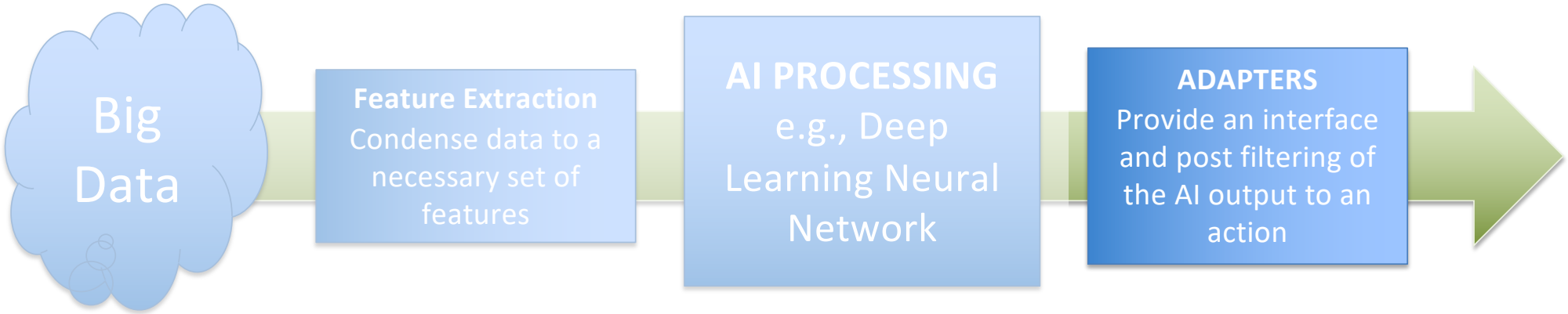
AI Processing



- **Supervised learning** occurs when the AI system is given training data sets where the desired output is known. The AI system then uses these data sets to learn to provide the desired output corresponding to the known input.
- **Unsupervised learning** is a type of machine learning (ML) where the system autonomously categorizes or describes the structure of "unlabeled" data.

Many different machine learning methods and algorithms are used.

Adapters – AI Subsystems



TYPES OF ADAPTORS:

- AI output can be provided in the form of recommendations or observations for human initiated actions (e.g., expert systems).
- AI output can directly control network behavior leveraging policy, existing rule engines, NFV/SDN and Software Defined capabilities.

Adaptors can be used to control the network or simply output recommendations.

Network Use Cases

- Network anomaly detection
- Network security
- Radio access network optimization
- Dynamic traffic and capacity management
- AI assisted orchestrated management
- AI based subscriber insights
- AI assisted customer support and sales
- AI based content processing and management

Conclusion

Themes emerging from applications of AI to the network:

- AI/ML will require **fundamentally new management and support models** for deployment:
  - Touching many, if not most, of business and operations processes
  - Education will be key to understanding how to manage these changes
- AI/ML focuses a bright light on **Network Data Exposure and APIs:**
  - AI/ML enables new ways to understand and use data, renewing the need for timely access to more unique data
  - AI/ML based automation will require better network APIs (making good use of NFV/SDN)
- How do we **create "network grade" AI** systems?
  - Use of aggregate systems of AI and other rules-based algorithms to maintain network integrity, responsibility, liability, etc.
  - Must account for public policy aspects of AI