Operating at the Edge Requires Resilient, Autonomous and Adaptive Technologies

DAFITC 2022

Mission Success and Survivability Using Distributed and Resilient Edge Situational Awareness

Stan Mo – SW Architect (Stan.Mo@intel.com)

Intel Federal and Aerospace Division, IOT/NEX Group

Agenda

- What is the Dynamic Edge and Situational Awareness
- Use Cases and Characteristics of the Edge
- What Is SADE?
- Demonstrations
- Summary

The Air and Space Edge

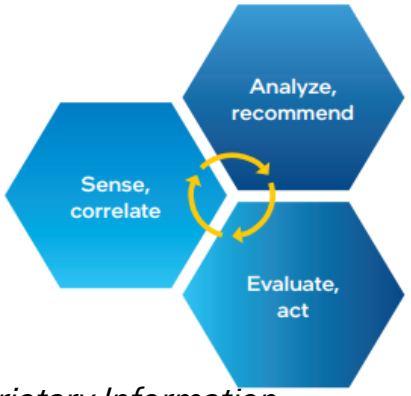
Common Challenges:

1. Latency sensitive, time critical SA info
2. Frequently limited power or comms
3. Edge tempos faster relative to cloud C2
4. Replacement cost vs Redundancy

Situational Awareness Priority

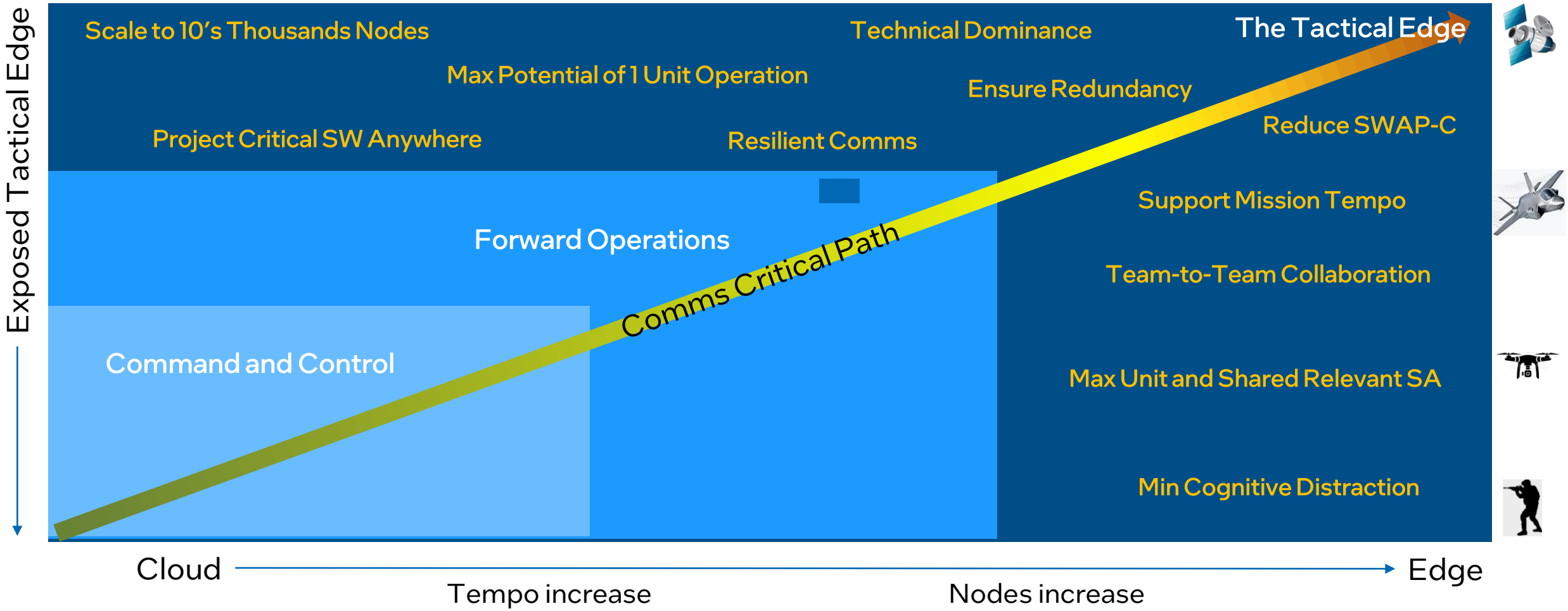
Comprehend & Analyze Current Environment

1. Rapid ***Sense, Analyze*** and Act
2. Relevant Data>Info>Recommendations
3. Minimize cognitive distraction
4. *Predict*



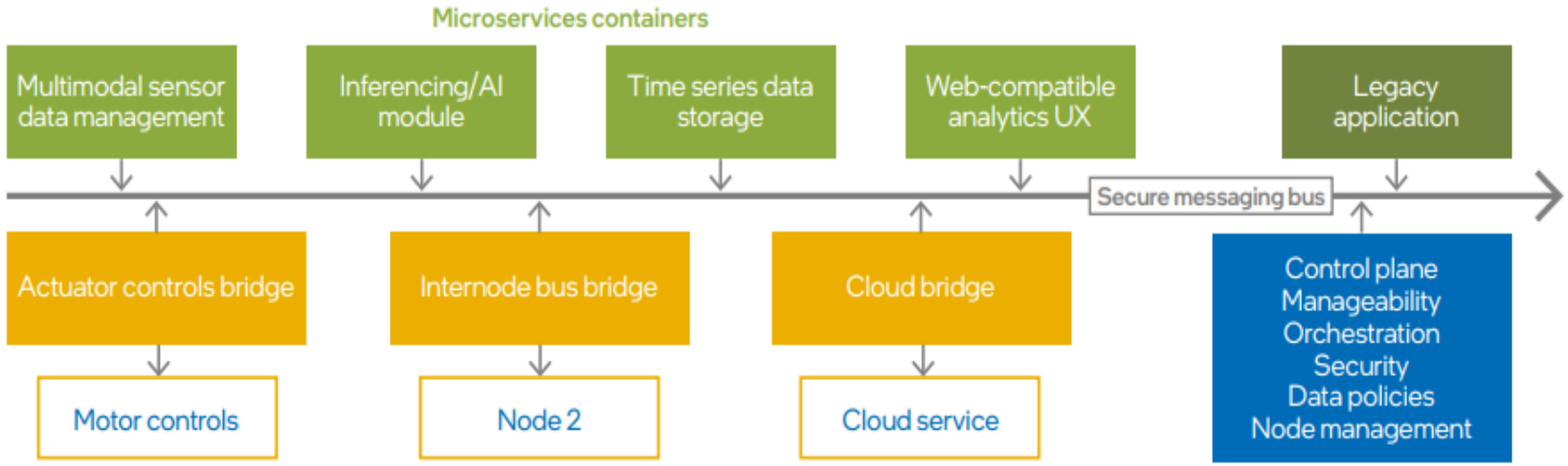
JADC2 Multi-Domain, Distributed Operation Continuum

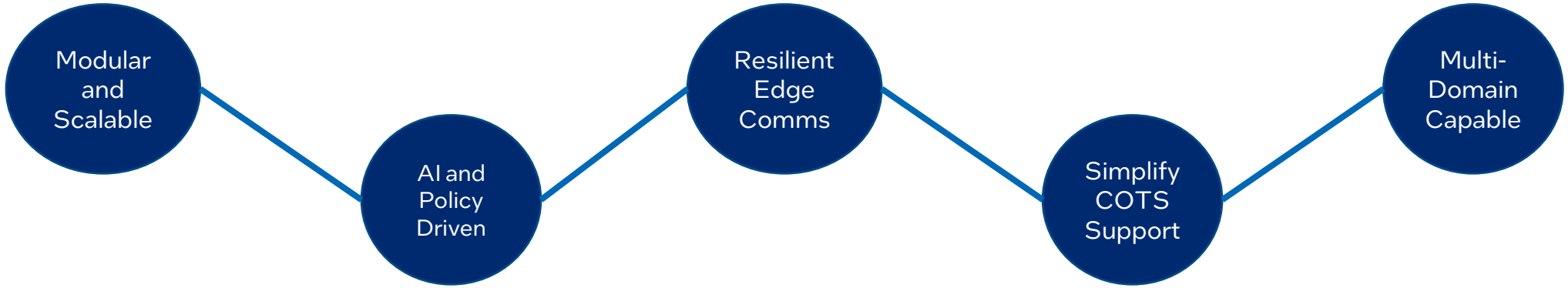
Critical Aspects for the Air/Space Tactical Edge



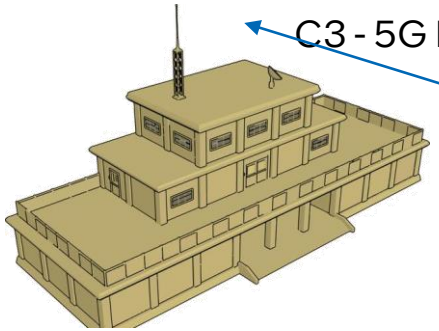
The AI-Backed Tactical Edge Must Be Resilient, Self-Supportive and Adaptive

Intel Situational Awareness at the Dynamic Edge (SADE)
Focus on AI-Backed Mission Operation and Asset Survivability



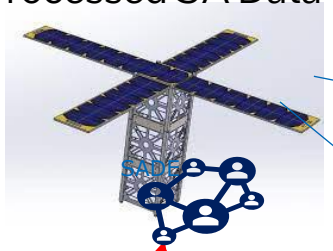


SADE SA Fabric – Resilient, Distributed, Secure Edge Autonomous Operations



C3 - 5G Point to Point

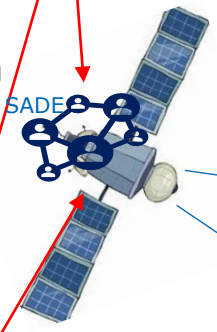
Edge Processed SA Data-stream



Secondary and Foveated Analytics / Recommendations

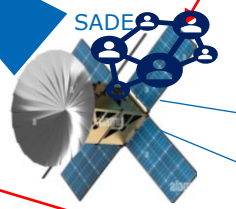
Edge AI processing

Data Formatting



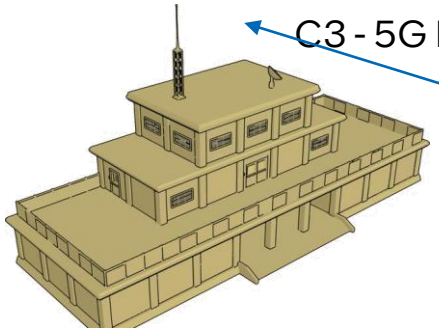
Fused sensor metadata

Relevant Data / information Routing



- Distributes analytics at the edge
- Optimizes data paths based on SA state
- Demand and topical relevance-based data routing

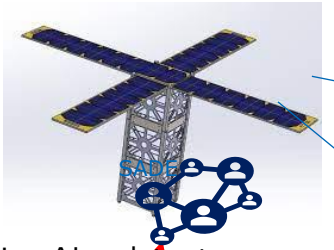
SADE SA Fabric – Autonomous Edge to Edge Operations



C3 - 5G Point to Point

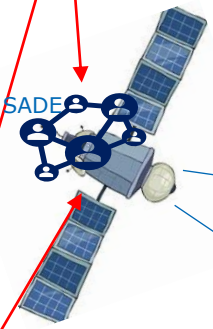
Updated mission SW, AI networks, policy, rules of engagement, etc.

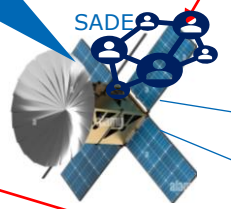
Updates can be passed among connected teams



Policy, AI updates to autonomous systems

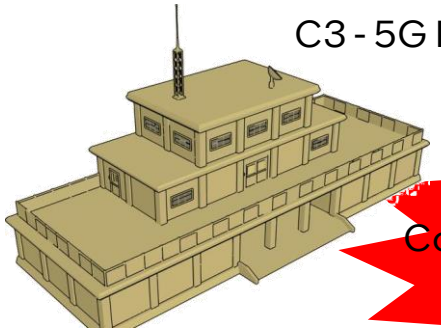
Automated caching of data and workloads





- Mission, policy and RoE updates
- Edge to Edge projection of SW asset
- SADE supports secure node to node updates in field

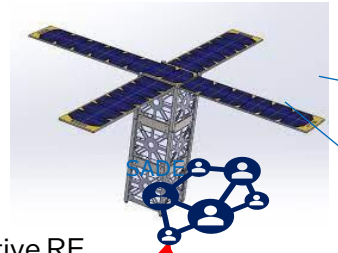
SADE SA Fabric – Policy and AI-Backed DDIL Mission Operations



C3 - 5G Point to Point

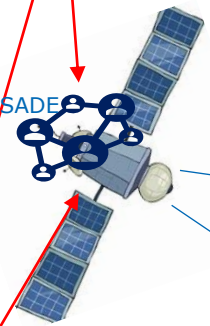
Comms suppression

Secured meshing, autonomous node clustering and local mission policy execution

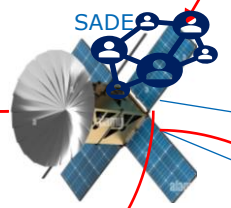


Adaptive RF comms – Min power and RF observability

Intelligent Demand Info Routing



Mission policy caching and management

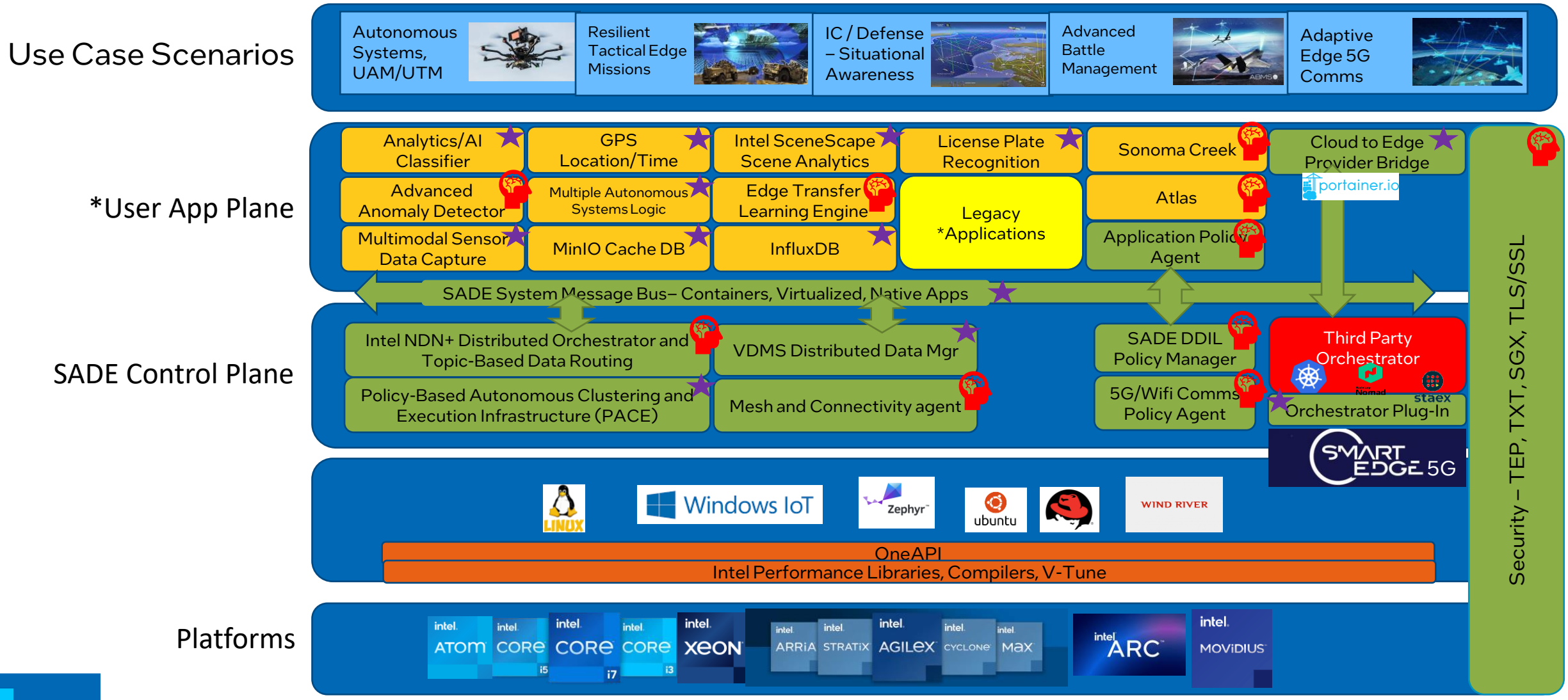


Transient node management

- DDIL initiates local node clustering and SA data management
- Policy and heuristics supports mission ops and unit survivability
- Scalable for transient nodes, meshing of friendly units and shadow comms

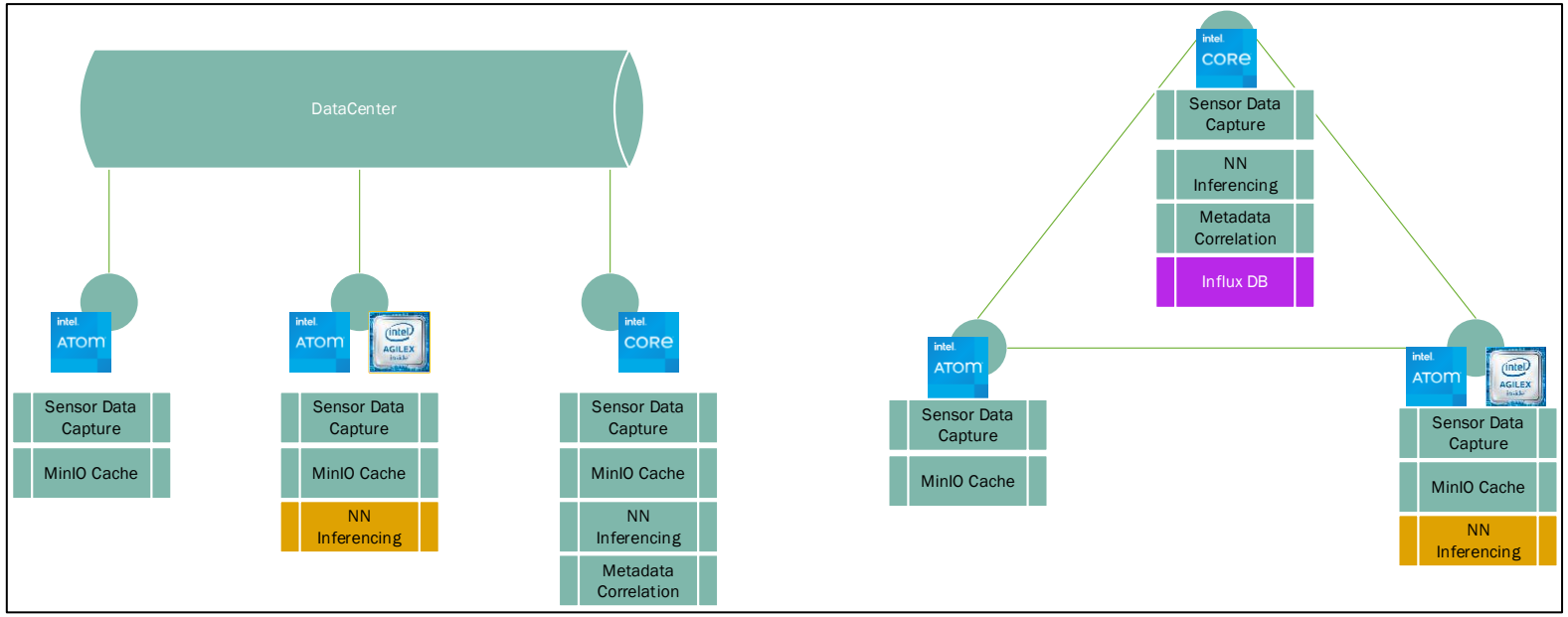
Intel SADE SW Framework Architecture

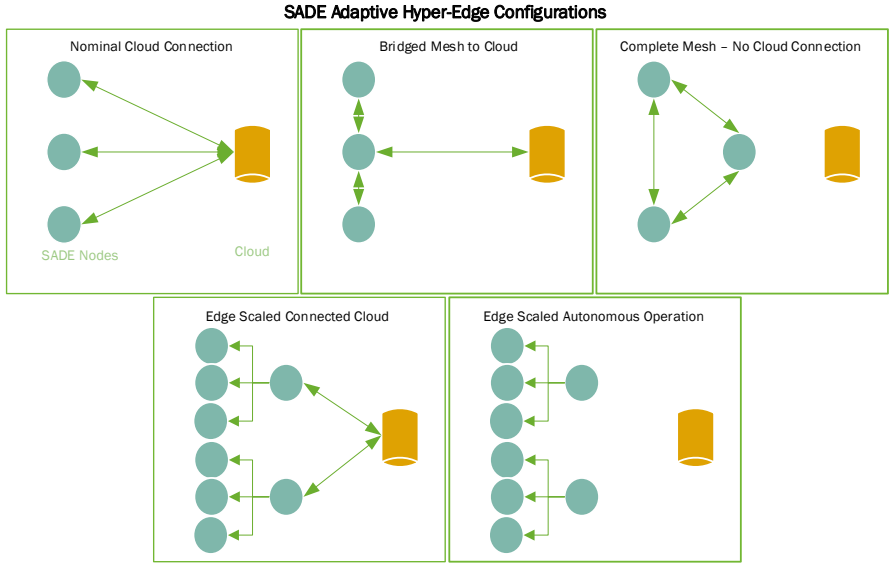
SADE - *Situational Awareness at the Dynamic Edge*



PACE – Policy-Based Autonomous Clustering Engine

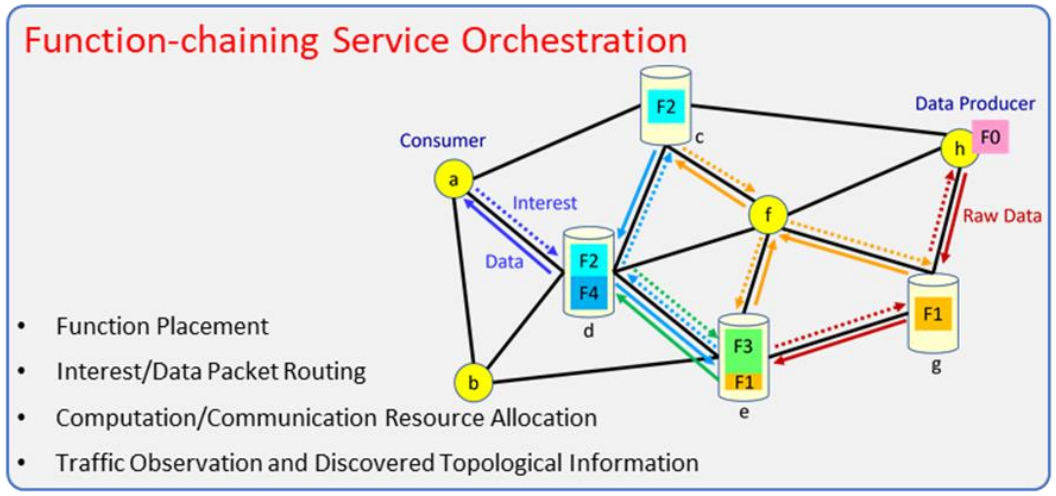
- Dynamic local auto-clustering of nodes upon cloud disconnect
- Policy directed comms meshing for nodes
- Edge independent operation / orchestration
- Bridge for edge to cloud asynchronous coordination with commercial systems





NDN Plus - Data Delivery to Full Resource Orchestration

SADE Named Data Networking Technology



Workload and Data Orchestration

- Enables integration of resource, telemetry and data orchestration while accounting for network and compute characteristics
- Lower CPU, Memory and Network utilization enables edge operation, high autonomy and adaptability to changing conditions

Data Routing / Networking

- Demand data by name / interest / topic
- Location independent and route scalable
- Caching possible at every node – algos, data, apps
- Pub/Sub, Multicasting capable

Secured Data Authenticity and Integrity

- Data packets are *digitally signed*
- Receivers/Consumers can verify data authenticity and integrity
- Digital certificates can be used to *establish trust on public keys*
- **No need for secure sessions for authenticity in highly kinetic and node transient environments**

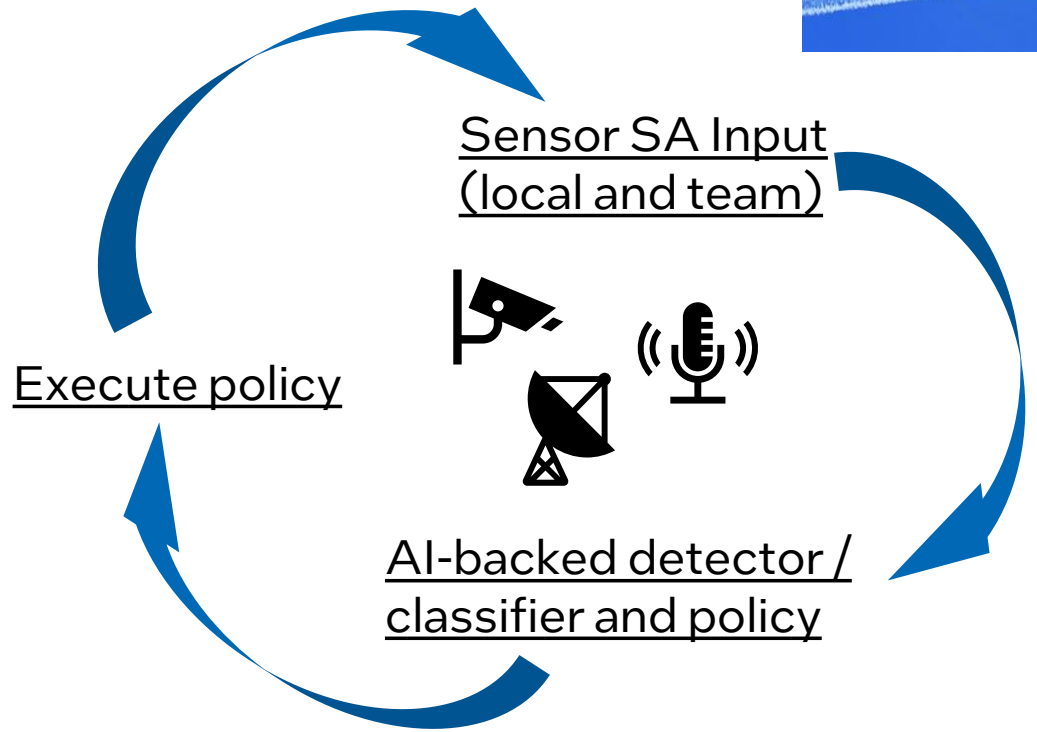
Intel NDN++

Distributed metadata*	Embedded Telemetry**	Resource Discovery*
Container execution*	Orchestration Engine*	Dynamic Routing**

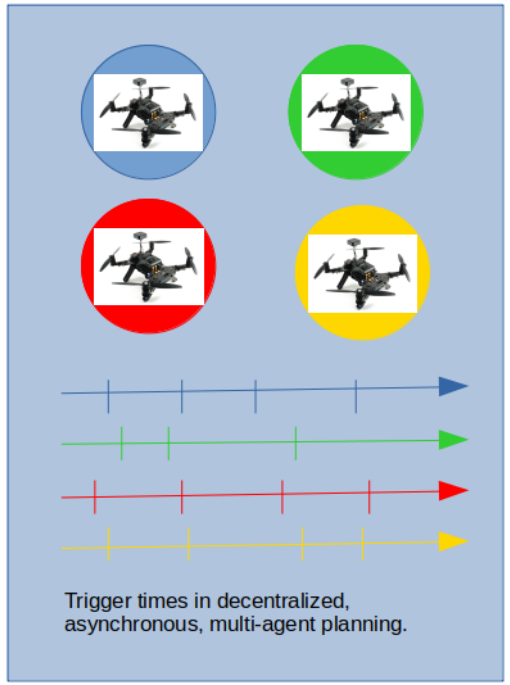
SADE Policy Manager – Adaptive Environmental Behavior

Multiple Level Adaptivity Driven by SADE SA Analytics and Policy

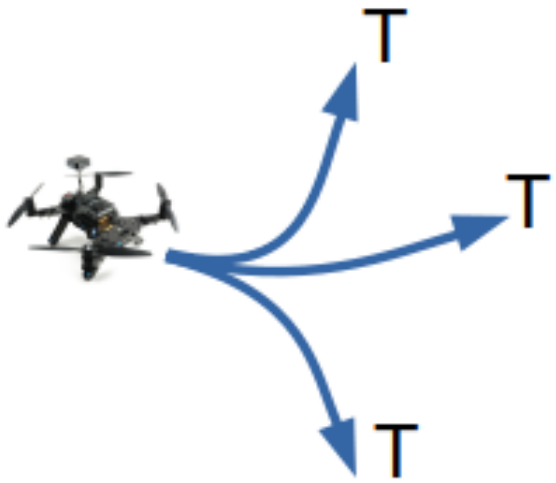
- SADE SA – React to/Predict local environment; optimize power, connectivity, lower RF observability
  - Multimodal sensor inputs
  - Local and team shared sensors
  - Policy-based responses
- 3 level policy modes
  - Application level – Message to apps to suspend, prioritize, filter operation – may be enforced by orchestrator
  - SADE framework – Control plane to priority modes – orchestrator, cloud bridge, verbose to quiet NDN mode
  - Communications – Min radio gain, targeted spectrum utilization, topology optimization (battery, packet traffic)



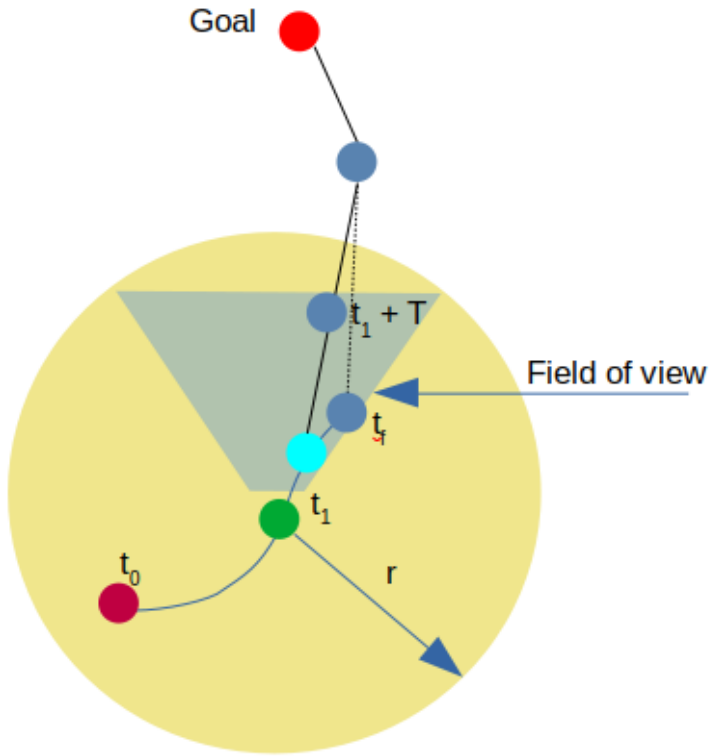
MAS Cooperative Autonomous Exploration



Cooperative exploration with asynchronous messaging for scalability. Implemented as a behaviour tree which can be adapted to other tasks.



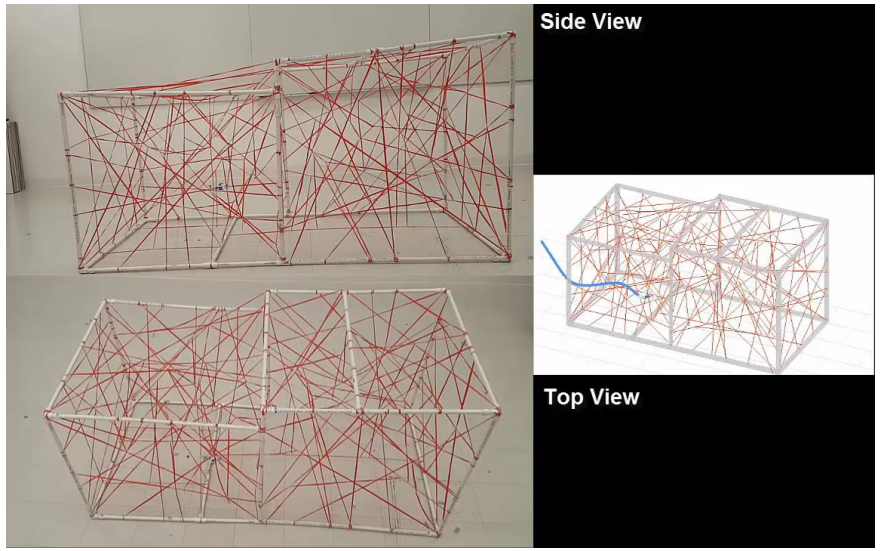
New method to generate motion primitives on the fly, with minimum energy & predefined time properties.



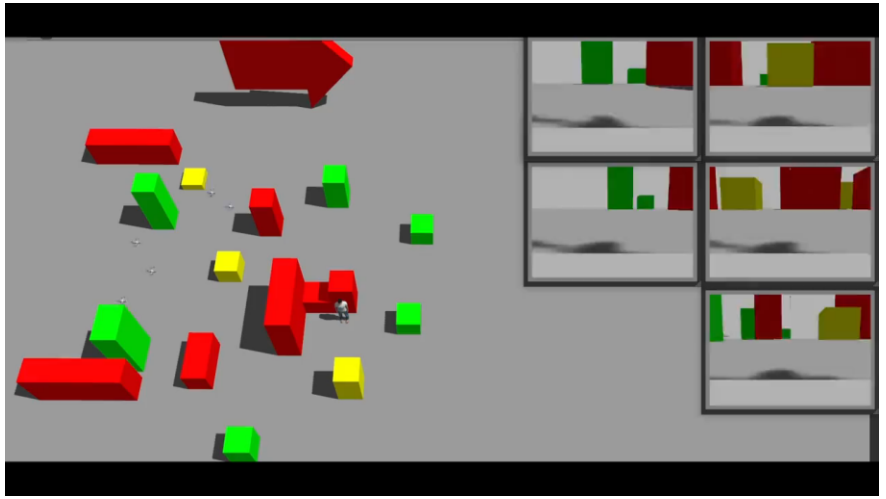
New decentralized multi-agent planning algorithm ensuring safe navigation with asymptotic optimality.

SADE Technology Proof of Concept

Central Nervous System for M2M Autonomous Platforms



Plotting courses through complex mazes



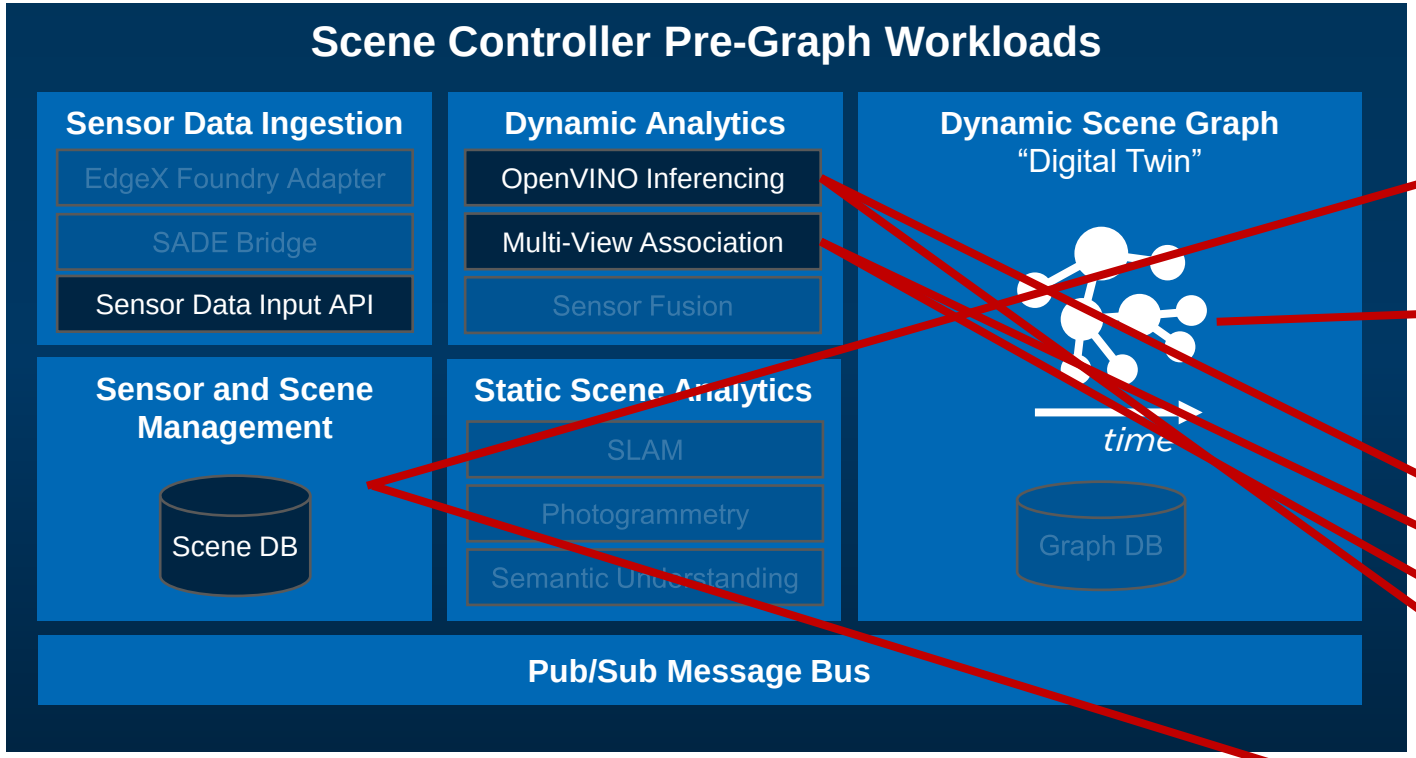
And autonomous team SAR mission tasking

Self-organizing tracking and orbiting of beaconing target

Intel SceneScape on SADE

Providing Scalable, Distributed Scene Intelligence at the Edge

Secured Perimeter and Autonomous Observation Capabilities



SADE + MAS + SceneScape Demonstration

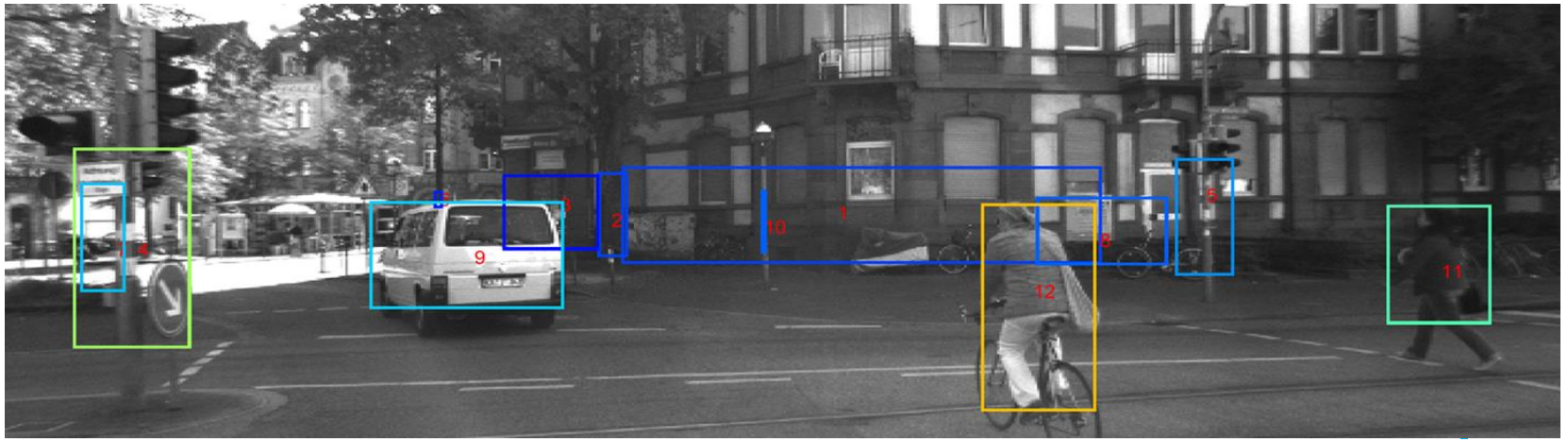
Chaining Multiple Functions on SADE Platform

Autonomous mapping and ISAR/P2P Tasking Operation

Advanced Anomaly Detection

Adaptive DBSCAN for Anomaly Detection

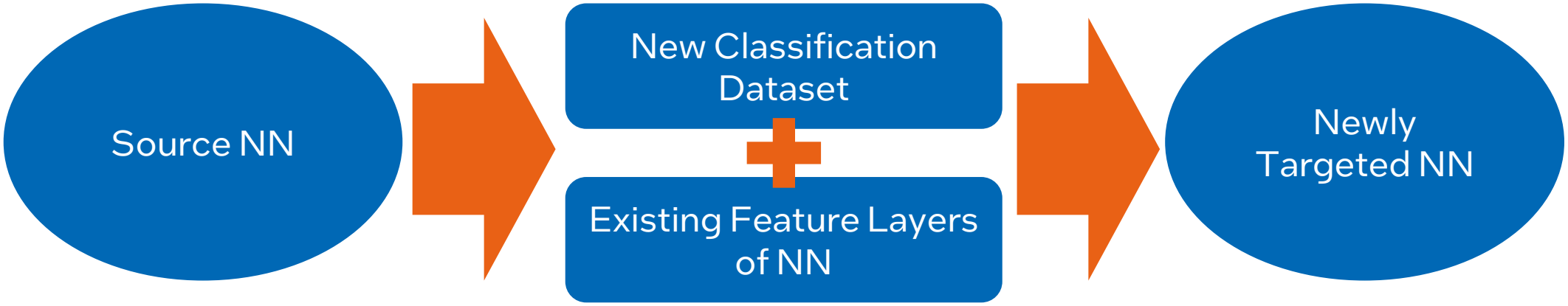
1. Based on a very efficient Unsupervised Machine Learning clustering algorithm, Density-Based Spatial Clustering of Applications with Noise (DBSCAN)
2. Intel modification increases the detection accuracy of the LIDAR by around 20-30%, by computing the clustering parameters adaptive to the distance from the LIDAR and to the distribution of the data in the LIDAR Field of View. This makes the method highly scalable across different deployment environments and scenarios.
3. The method has been tested successfully for both 2D and 3D LIDARs and for indoor, outdoor robot and drone applications
4. Object identification and Tracking has been successfully done based on the features extracted from the object clusters.



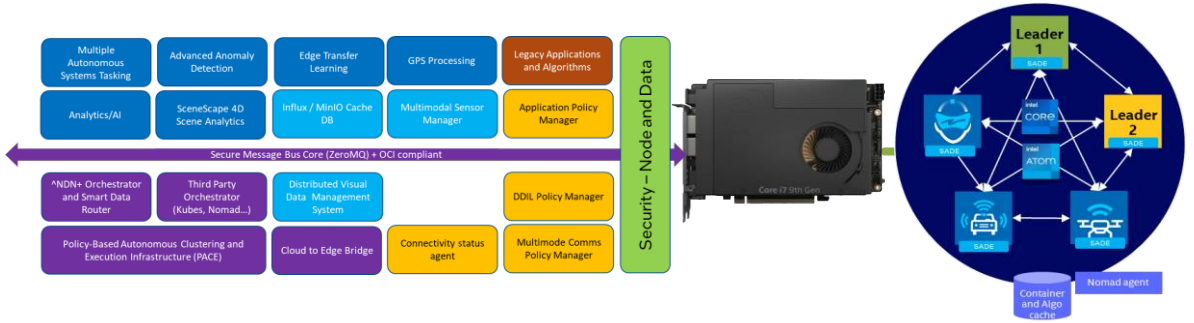
Edge Transfer Learning Project

Exploring Techniques to Train and Update Field NN to New Threats

- Utilize the backbone and feature detection layers of a trained NN
- Retrain the classification layer with small annotated datasets at the edge
- Allows more rapid identification of new objects *and distribution between nodes at the Edge*
- May not require training a new NN at the datacenter using large datasets



Summary



- In Summary
  - SADE is modular, scalable and autonomous SW infrastructure enabling rapid, development and deployment of apps/functions at the edge. Enables the projection of critical SW capabilities across the theatre of operation. Early customer evaluation is underway.
  - SADE adapts through policy to changing conditions providing mission resilience in DDIL, clusters nodes for greater flexibility, handles transient nodes and topical data messaging and management in “Edge to Edge” environments
  - SADE simplifies integration and optimization of the latest SW technologies and applications with legacy capabilities on COTS systems. Speeds upgradeability to newest platforms.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