



AGENTS IN INDUSTRY AND COLLABORATION

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WOA 2019, 27.06.2019, Parma

Two MAS aspects for our first twenty years, and the next batch


- + Organizing principle for software architectures
 - From 1999 to 2019, how has software (engineering) changed?
 - What has been the impact of multi-agent systems ideas and practice?
- + Organizing principle for human+machine intelligent systems
 - Collaborative, distributed, open, incomplete, multi-disciplinary
 - Artificial Intelligence from a European perspective
 - A Europe-wide (and beyond) example: the WeNet project

1999 JADE

HIPSTER-RETRO, WITH VINTAGE GRAPHICS

Just Open Sourced (jade.io?)

Distributed and Containerized



JADE What is JADE ?

- A FIPA-compliant agent platform.
- A Java framework for the development of Multi Agent Systems.
- An Open Source project, © CSELT, LGPL license.
 - JADE is a joint development of CSELT and the DII of Parma University.
 - Project home page: <http://sharon.csel.it/projects/jade>

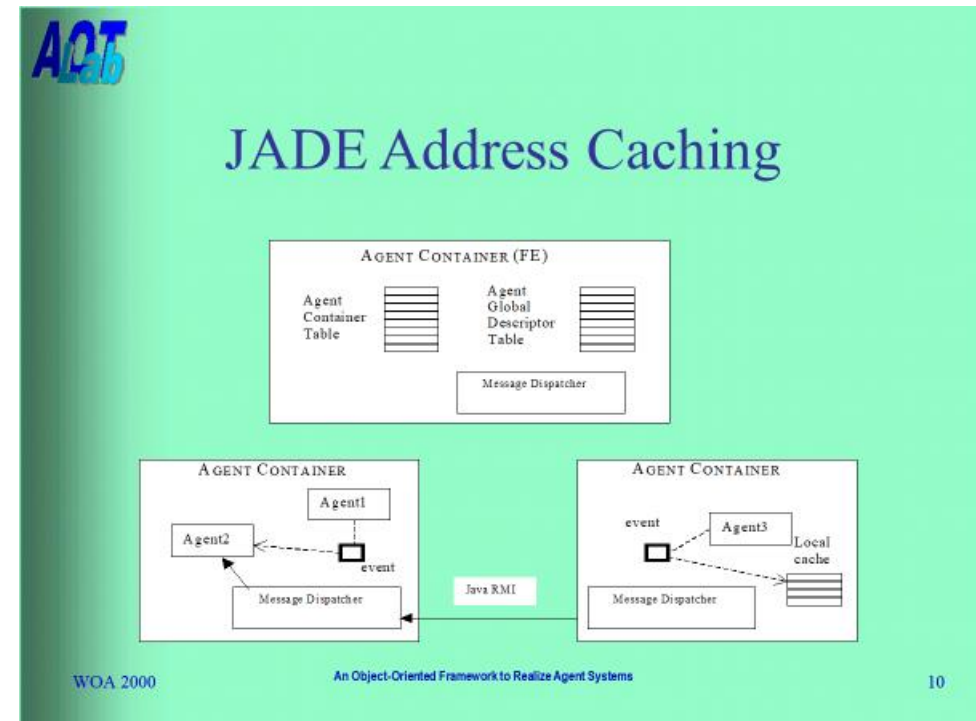
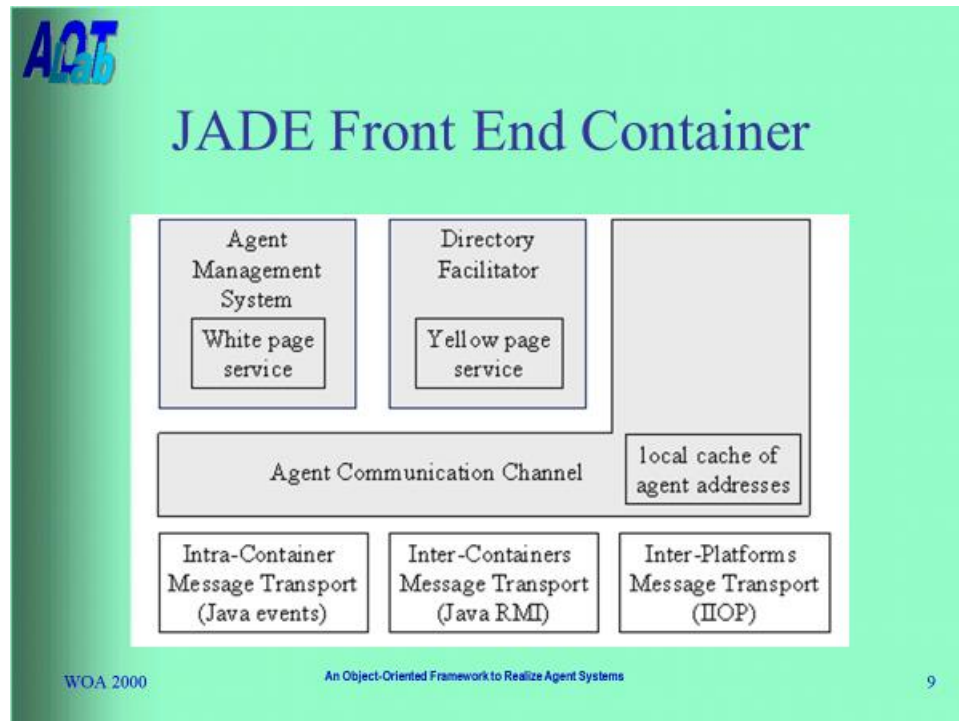
WOA 2000 An Object-Oriented Framework to Realize Agent Systems 2



HIPSTER-RETRO, WITH VINTAGE GRAPHICS

Service- and Message-based

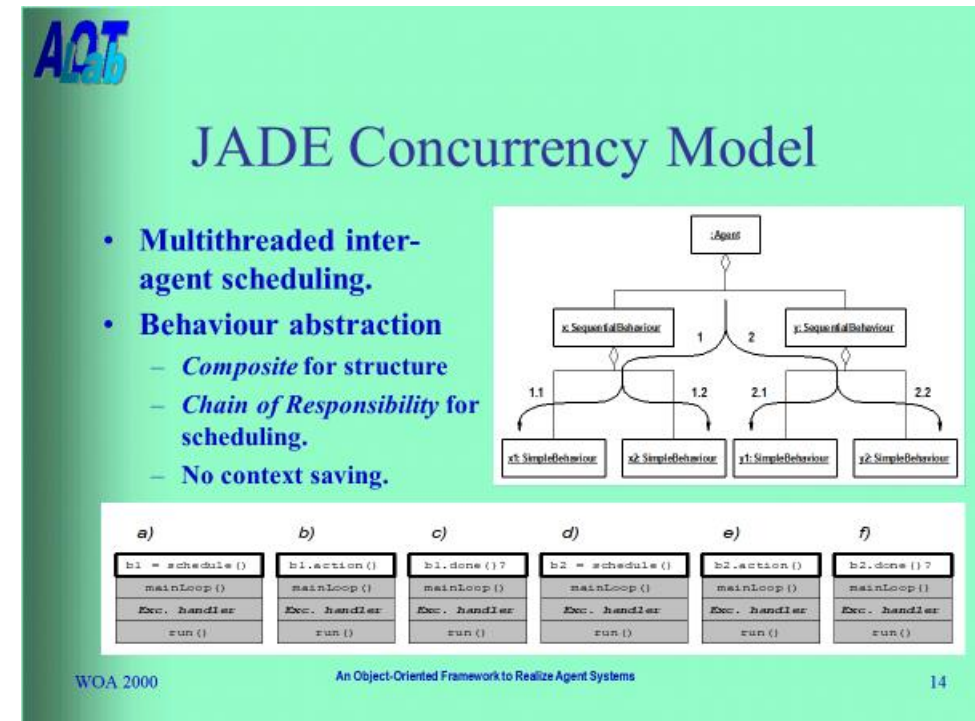
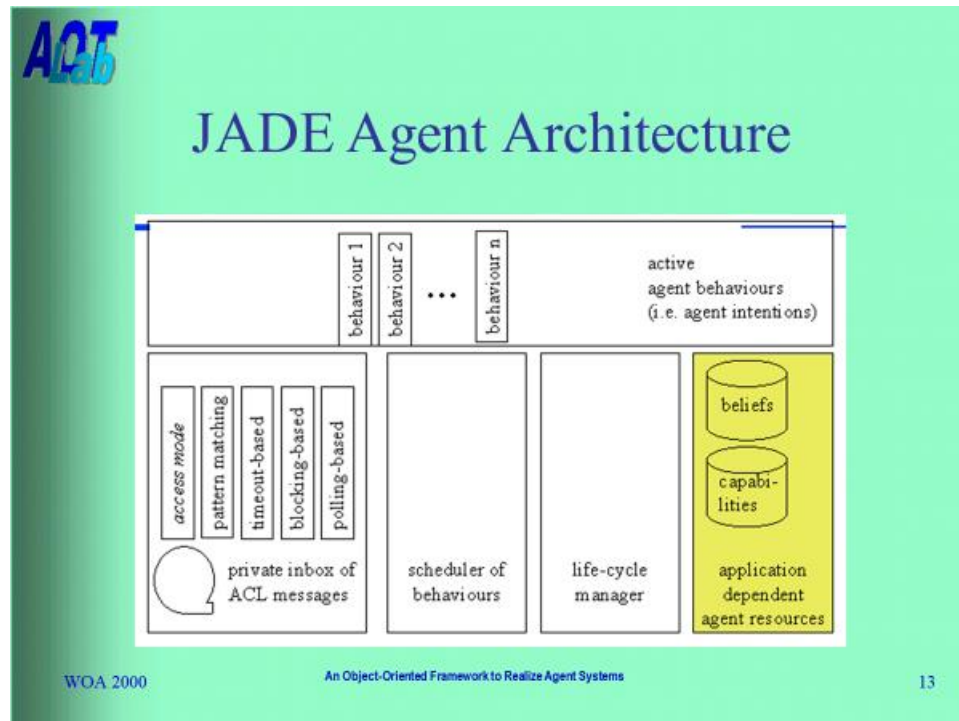
Enterprise Event Bus Included



HIPSTER-RETRO, WITH VINTAGE GRAPHICS

Active Component Model

Continuation-based Scheduling



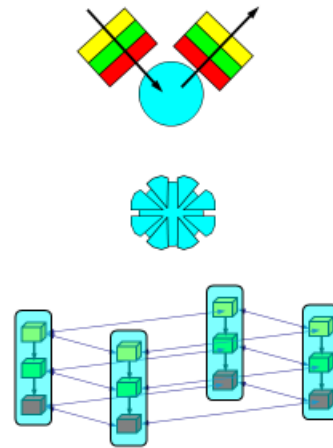
Multi-Node Services

Independent Scalability



Towards The Solution

- CFs intercept the methods of an object.
 - Incoming and outgoing.
- JADE provides tunable location transparency.
 - Peer-to-peer relationship among containers.
 - N-way Half-Object Plus Protocol Pattern.
- Combining the two:
 - Distributed Coordinated Filters.



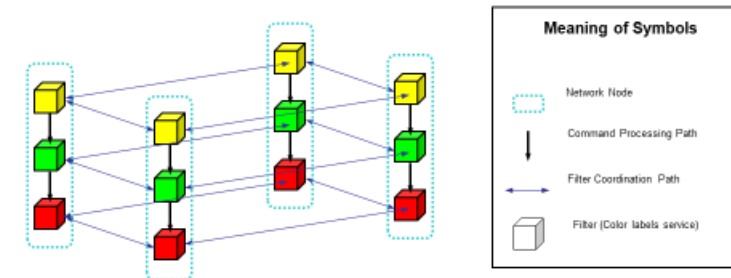
FRAMeTech

JADE Board Meeting – Turin, October 27th, 2003

G. Rimassa – JADE Service Architecture



Distributed Coordinated Filters



- The major concepts, in principle, are:
 - Service, Command, Filter (**Processing** aspect).
 - ServiceSlice, Node (**Distribution** aspect).
 - ServiceInteraction, ServiceProtocol (**Introspection** aspect).

FRAMeTech

JADE Board Meeting – Turin, October 27th, 2003

G. Rimassa – JADE Service Architecture

HOW MAS-BASED? WHAT'S VALID, WHAT CHANGED?



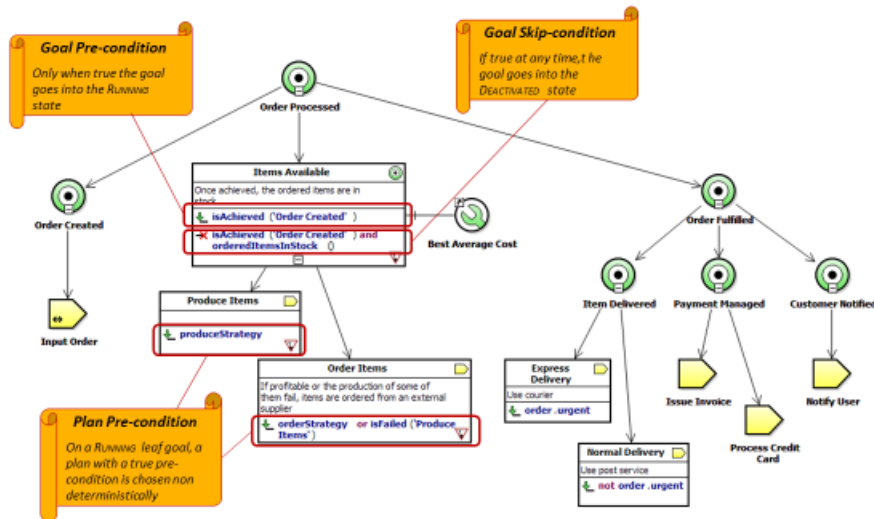
JADE: Original baseline of that vision of MAS, but still evolving

2009 LSPS

Simple BDI-inspired Model

Active Objects, Continuations

Agents for BPM – Process Modeling



WOA 2010 mini-school | v1.0 | 2010-09-01 | GRI

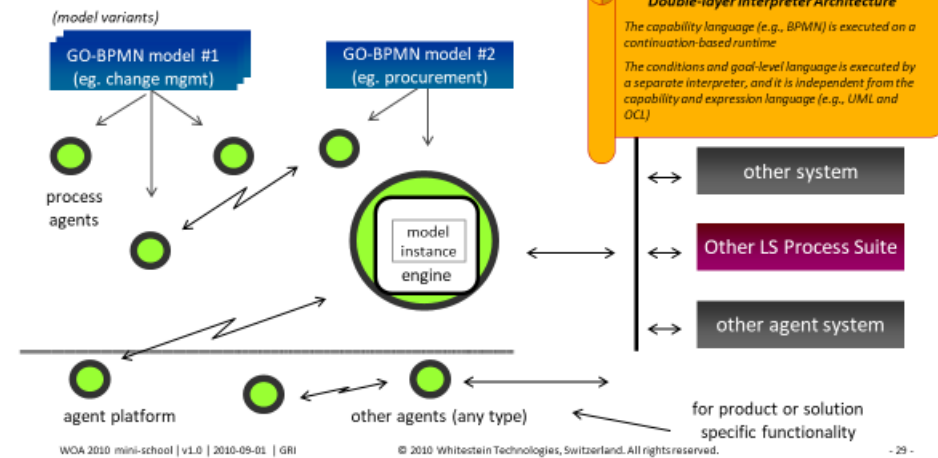
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Agents for BPM – Process Execution



- ❑ **Multi-Agent System BDI-like Engine**
- ❑ **Each process instance is handled by a single agent**, which continuously executes an autonomic "perceive-decide-plan-execute" loop

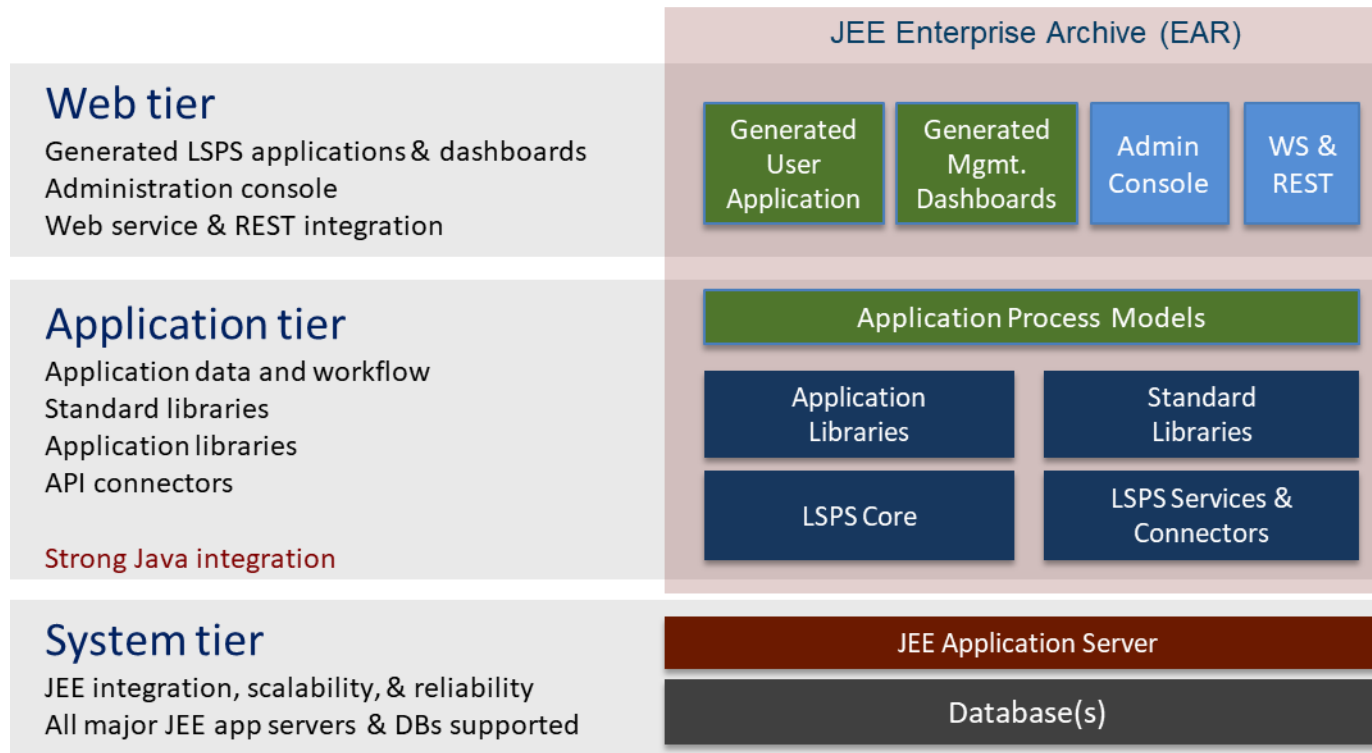


WOA 2010 mini-school | v1.0 | 2010-09-01 | GRI

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LSPS STANDARDS-BASED ARCHITECTURE



- + JEE scalability & reliability guarantees
- + Micro-services architecture coming in LSPS 4.0 (2019)
- + On-premises or cloud deployment

LSPS FOR INTELLIGENT SCM (2016 - 2017)

Quest: Site Planner of the Future (20+ years)

P&G + DXC Project

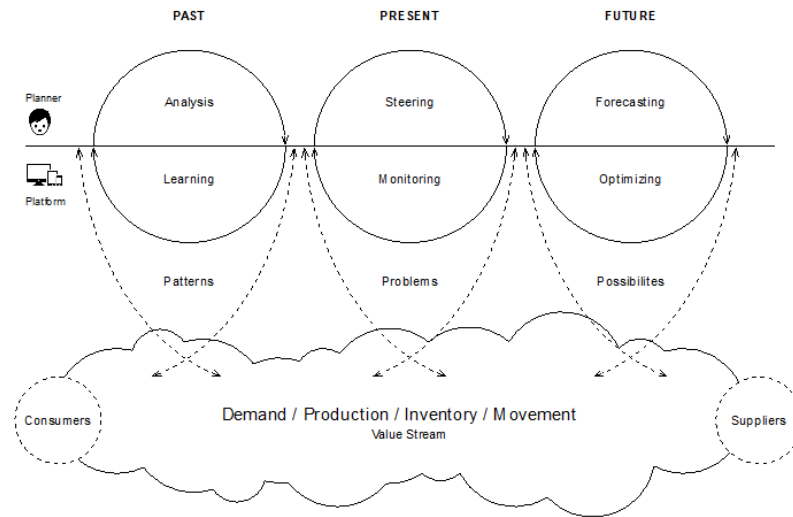
Guiding Values

An End-to-End Planner

- Empowered
- Productive
- Strategic
- Insightful
- Innovative
- Mobile
- Relaxed

The Planner's Platform

- End-to-End
- At the Speed of the Business
- Transparently Intelligent
- Automated, but Configurable
- Auditable, Secure & Verifiable
- "What-if-able"
- Clear and Quiet



Assumptions

Standardization and codification of business practices throughout the value stream. Internal and external data currently not in the system has been introduced to achieve maximum performance and value.

Value Proposition

20% Strategic Planning	→	80% Strategic Planning
80% Firefighting	→	20% Firefighting

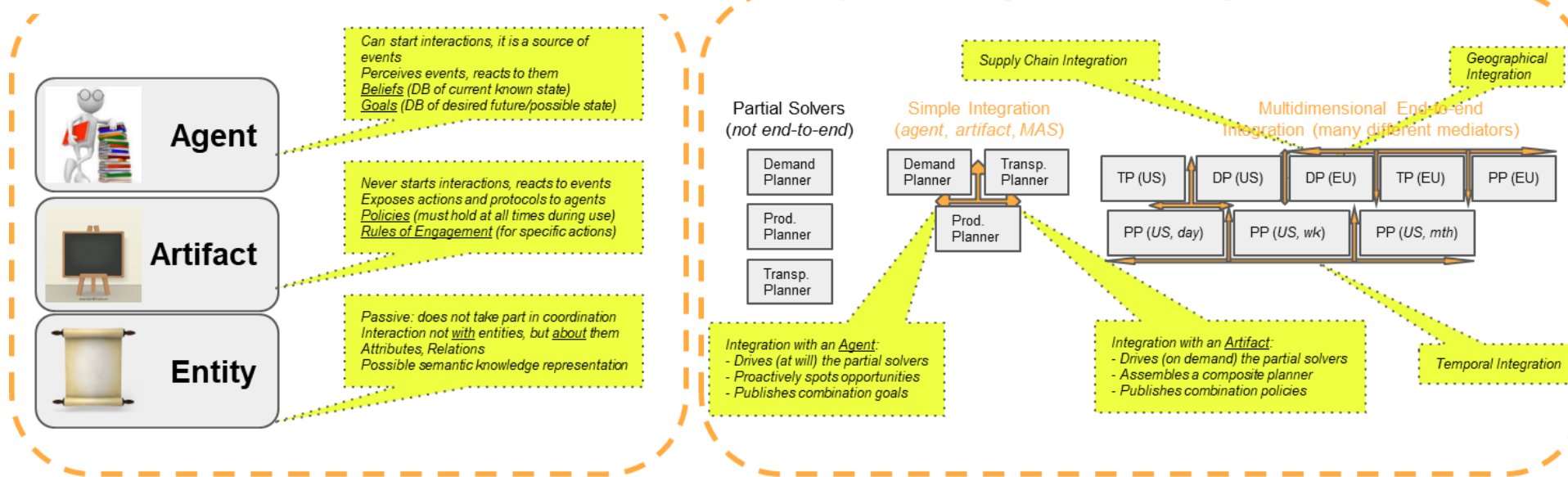
- Analysis
- Communication
- Collaboration
- Forecasting
- Modeling

- + Multi-domain plans
- + Existing "Lego Bricks"
- + Distributed networks
- + Multi-level KPIs
- + Less firefighting
- + More speculative work

SOLUTION ARCHITECTURE: CONCEPTUAL METAMODEL

Architecture Components

Taxonomy for MAS components (interaction/coordination)



Open and extensible architecture

- ❖ Better blocks can replace older ones
- ❖ Blocks can be combined dynamically
- ❖ New blocks expand end-to-end reach
- ❖ Agents can process representations
- ❖ Goals, policies, constraints, etc. as data

Rich metadata as major enabler

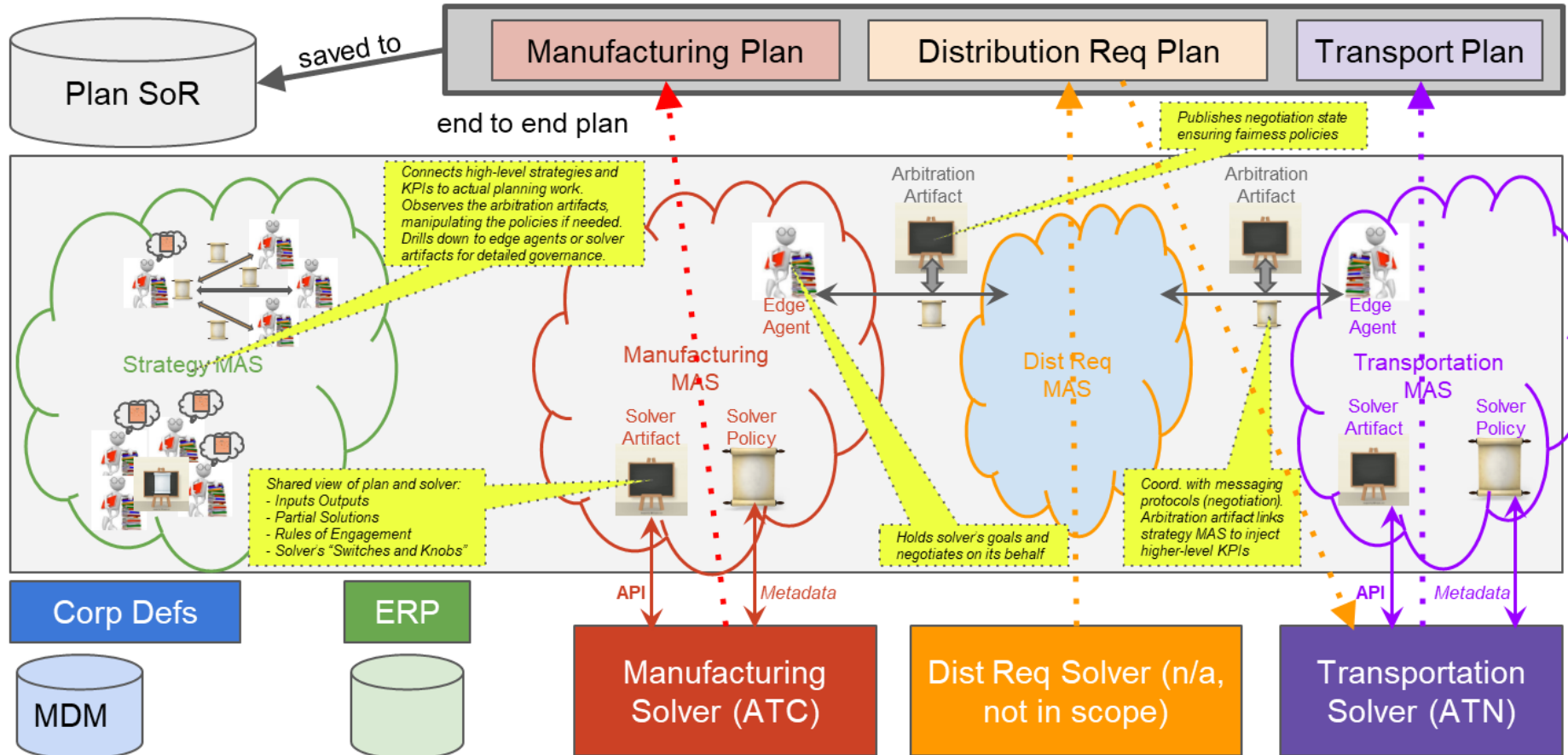
- ❖ **Event Ontology** - Describes possible ϵ
- ❖ **Action Ontology** - Describes possible δ
- ❖ **Knowledge/Data Ontology** - Describes possible entities
- ❖ **Architecture Ontology** - Reflection layer: describes itself

Mining ontological elements

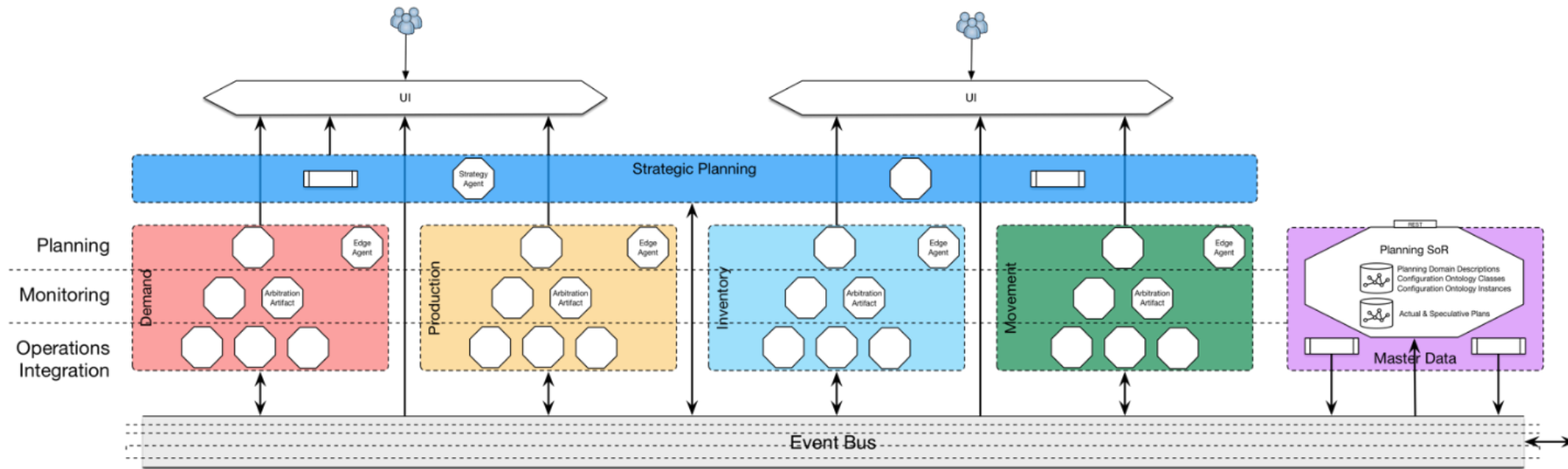
- ❖ Real Ontologies (e.g., from W3C)
- ❖ Description Languages
- ❖ Reference Models
- ❖ Direct in-house knowledge

SOLUTION ARCHITECTURE: HIGH LEVEL DESCRIPTION

MAS Interaction in E2E Planning (PoC Scenario)



SOLUTION ARCHITECTURE: CONCRETE REALIZATION



A new domain for strategic planning is present in the overall diagram

- It contains *Strategy Agents*, as well as other (Lego bricks, specific services, etc.) components with cross-domain scope

Operational domains have elements (e.g., *Arbitration Artifact*) that can be observed by strategy agents

- A (conceptually) shared Artifact enables public commitment and independent safety check for cross-domain interactions

The planning System of Record holds ontologies (classes and instances) that can be used for policy check

- Relying on standard languages as OWL2 and PDDL, stored in the most convenient way for the platform

Strategic Goals for global KPIs

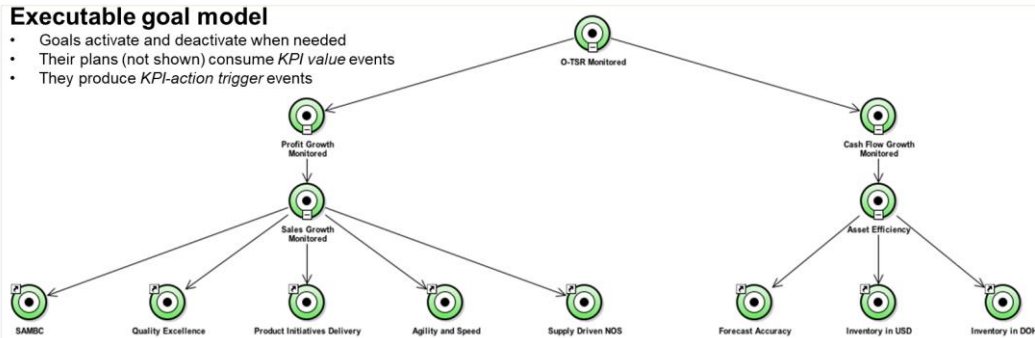
Agents have an explicit representation of their goals and can act on them. They perceive events and engage in cooperative behavior with other agents and services

- At the highest Strategic Level, these goals align with the overarching KPIs and business objectives
- Agents at this level aggregate simpler events and KPIs to reach overall measurements
- Moreover, they hold the target values, thresholds, and policies used to govern execution

A Strategy Level goal tree provides a **stable, overarching set of business goals**

Executable goal model

- Goals activate and deactivate when needed
- Their plans (not shown) consume KPI value events
- They produce KPI-action trigger events

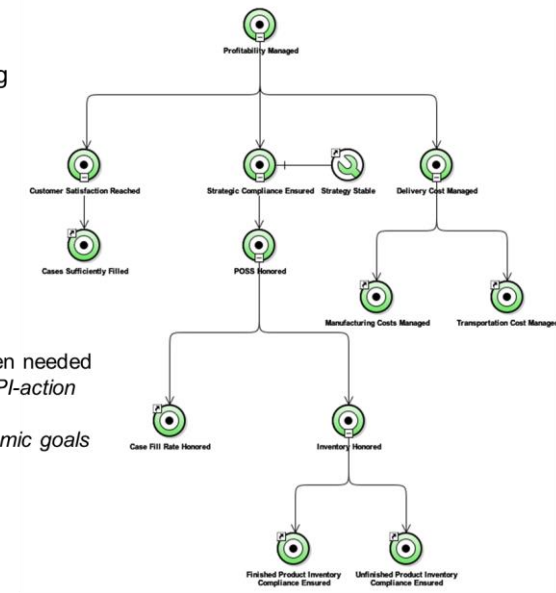


Agent PGs adapt to the context

- Beyond a single strategy goal tree, direction is passed via agent messaging to **tactical-level goal trees**.
 - Working on KPIs with limited scope
 - Responding to strategic directions
 - Reacting to operational events
 - Directing/policing relevant services

Executable goal model

- Goals activate and deactivate when needed
- They consume operational and KPI-action trigger events
- They adopt and drop *ad-hoc dynamic goals* (not shown)



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DEMO APPLICATION (2016 - 2017)

Inventory shortage trigger

MANIPULATE INVENTORY

Manipulate Inventory at Locations and Observe Rebalancing

Distribution Network Inventory Levels

Chosen Location

Location Code: **B341**

Location Name: **Dallas Mixing Center**

Product Name: DAWN ORIGINAL, 12/BOZ

Product SKU: **80257885**

Available: **500**

Promised: **0**

Committed: **0**

Safety Level: **882**

Low Threshold: **441**

Enter Amount (cases)

Consume Stock Order submitted for 100 CS of Product SKU: 80257885

Dallas Mixing Center

Leaflet | Map data © OpenStreetMap contributors

Cooperation ensues

COORDINATION SNIFFER

Subject: Inventory Rebalancing

Conversations

<clear>

B341 needs 482 80257885 for the lowest cost (IN PROGRESS)

PROPOSE/RE... ACCEPT/REJ... FINISHED

Messages

cfp from Dallas Mixing Center to all [2016-08-19 02:59:19]

propose from West Coast Mixing Center to Dallas Mixing Center [2016-08-19 02:59:21]

propose from Edwardsville Supply Warehouse to Dallas Mixing Center [2016-08-19 02:59:21]

propose from Kansas City Plant to Dallas Mixing Center [2016-08-19 02:59:22]

Message content

```
{
  "seconds" : 0,
  "millis" : 0
},
"refuseReason" : null,
"proposedValue" : 482
}
```

propose from West Coast Mixing Center to Dallas Mixing Center [2016-08-19 02:58:21]

Leaflet | Map data © OpenStreetMap contributors

DEMO APPLICATION (2016 - 2017)



Keeping Humans in the Loop: the system generates, evaluates, and proposes feasible solutions

P&G [To-do List](#) Documents Run Model admin

CHOOSE THE SOLUTION TO ACCEPT

Choose the Preferred Solution:

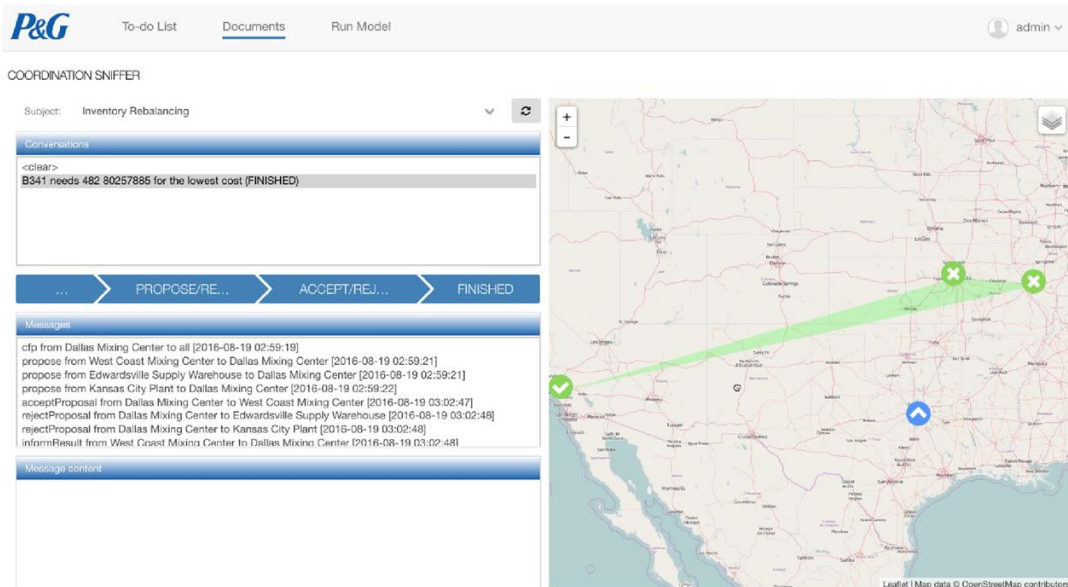
Needed at Site: B341 Only Minimal Solutions
SKU: 80257885 Allow CUT in Solutions
Requested Amount: 482

Candidate Solutions

Solution ID	eeec4c69-aa23-4884-ab	Solution ID	c62ca99c-e02c-405f-8e4	Solution ID	9f9db664-be03-4f93-bb4	Solution ID	f513ed62-a311-4a9d-a24	Solution ID	cab0f308-7baf-4099-948	Solution ID	717068d9-2321-4108-ac	Solution ID	53120ca6-18f0-42df-bde
Total Cost	1219	Total Cost	1370.585	Total Cost	1874.454	Total Cost	1878	Total Cost	2352	Total Cost	2398.165	Total Cost	3011
MOVE 482 CS from B275 - [cost 1219]	MOVE 77 CS from 2585 - [cost 659] CUT 405 CS - [cost 711.585]	MOVE 60 CS from 1729 - [cost 1133] CUT 422 CS - [cost 741.454]	MOVE 77 CS from 2585 - [cost 659] MOVE 482 CS from B275 - [cost 1219]	MOVE 60 CS from 1729 - [cost 1133]	MOVE 77 CS from 2585 - [cost 659] CUT 345 CS - [cost 606.165]	MOVE 60 CS from 1729 - [cost 1133]	MOVE 77 CS from 2585 - [cost 659] MOVE 482 CS from B275 - [cost 1219]	MOVE 77 CS from 2585 - [cost 659] MOVE 60 CS from 1729 - [cost 1133]	MOVE 60 CS from 1729 - [cost 1133] MOVE 482 CS from B275 - [cost 1219]				
<input type="button" value="CHOOSE"/>	<input type="button" value="CHOOSE"/>	<input type="button" value="CHOOSE"/>	<input type="button" value="CHOOSE"/>	<input type="button" value="CHOOSE"/>	<input type="button" value="CHOOSE"/>	<input type="button" value="CHOOSE"/>	<input type="button" value="CHOOSE"/>	<input type="button" value="CHOOSE"/>	<input type="button" value="CHOOSE"/>				

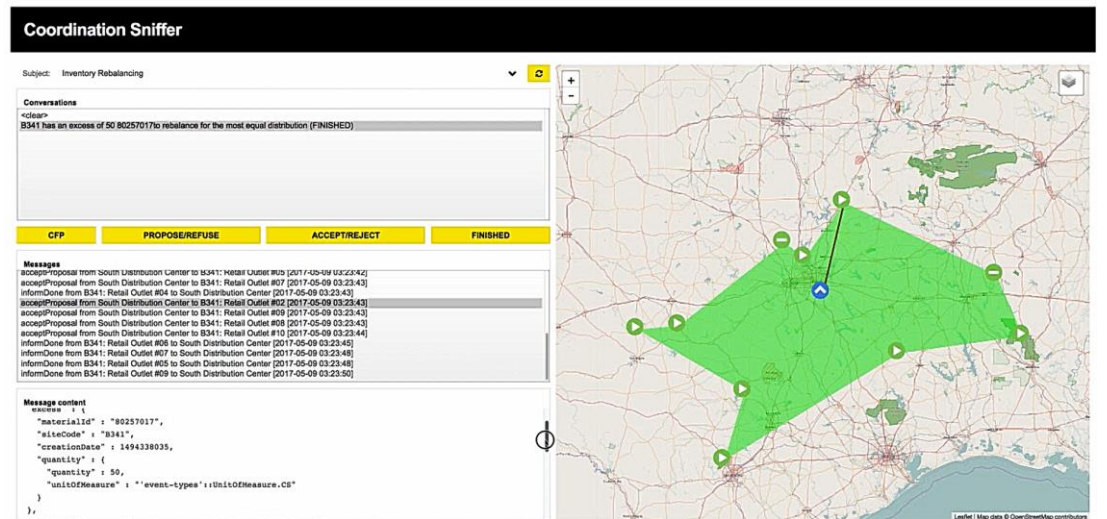
DEMO APPLICATION (2016 - 2017)

Agent interaction completes



The screenshot shows the P&G Coordination Sniffer interface. At the top, there are navigation tabs: "To-do List", "Documents", and "Run Model". The user is logged in as "admin". The main window is titled "COORDINATION SNIFFER" and has a subject of "Inventory Rebalancing". On the left, there is a "Conversations" panel with a "clear" button and a message: "B341 needs 482 80257885 for the lowest cost (FINISHED)". Below this is a flow diagram with four stages: "...", "PROPOSE/RE...", "ACCEPT/REJ...", and "FINISHED". The "FINISHED" stage is highlighted. Below the flow diagram is a "Messages" panel with a list of messages, including "cfp from Dallas Mixing Center to all [2016-08-19 02:59:19]", "propose from West Coast Mixing Center to Dallas Mixing Center [2016-08-19 02:59:21]", "propose from Kansas City Plant to Dallas Mixing Center [2016-08-19 02:59:22]", "acceptProposal from Dallas Mixing Center to West Coast Mixing Center [2016-08-19 03:02:47]", "rejectProposal from Dallas Mixing Center to Kansas City Plant [2016-08-19 03:02:48]", "rejectProposal from Dallas Mixing Center to Edwardsville Supply Warehouse [2016-08-19 03:02:48]", and "informResult from West Coast Mixing Center to Dallas Mixing Center [2016-08-19 03:02:48]". Below the messages is a "Message content" panel. On the right, there is a map of the United States with a green shaded area and several markers (green 'x', blue 'u', green 'v').

Tools show what's going on



The screenshot shows the Coordination Sniffer interface. At the top, there are navigation tabs: "To-do List", "Documents", and "Run Model". The user is logged in as "admin". The main window is titled "COORDINATION SNIFFER" and has a subject of "Inventory Rebalancing". On the left, there is a "Conversations" panel with a "clear" button and a message: "B341 has an excess of 50 80257017 to rebalance for the most equal distribution (FINISHED)". Below this is a flow diagram with four stages: "CFP", "PROPOSE/REFUSE", "ACCEPT/REJECT", and "FINISHED". The "FINISHED" stage is highlighted. Below the flow diagram is a "Messages" panel with a list of messages, including "acceptProposal from South Distribution Center to B341: Retail Outlet #02 [2017-05-09 03:23:43]", "acceptProposal from South Distribution Center to B341: Retail Outlet #03 [2017-05-09 03:23:43]", "acceptProposal from South Distribution Center to B341: Retail Outlet #04 [2017-05-09 03:23:43]", "acceptProposal from South Distribution Center to B341: Retail Outlet #05 [2017-05-09 03:23:43]", "acceptProposal from South Distribution Center to B341: Retail Outlet #06 [2017-05-09 03:23:43]", "acceptProposal from South Distribution Center to B341: Retail Outlet #07 [2017-05-09 03:23:43]", "acceptProposal from South Distribution Center to B341: Retail Outlet #08 [2017-05-09 03:23:43]", "acceptProposal from South Distribution Center to B341: Retail Outlet #09 [2017-05-09 03:23:43]", "acceptProposal from South Distribution Center to B341: Retail Outlet #10 [2017-05-09 03:23:44]", "informDone from B341: Retail Outlet #02 to South Distribution Center [2017-05-09 03:23:45]", "informDone from B341: Retail Outlet #03 to South Distribution Center [2017-05-09 03:23:45]", "informDone from B341: Retail Outlet #04 to South Distribution Center [2017-05-09 03:23:45]", "informDone from B341: Retail Outlet #05 to South Distribution Center [2017-05-09 03:23:45]", "informDone from B341: Retail Outlet #06 to South Distribution Center [2017-05-09 03:23:45]", "informDone from B341: Retail Outlet #07 to South Distribution Center [2017-05-09 03:23:45]", "informDone from B341: Retail Outlet #08 to South Distribution Center [2017-05-09 03:23:45]", and "informDone from B341: Retail Outlet #09 to South Distribution Center [2017-05-09 03:23:45]". Below the messages is a "Message content" panel with the following JSON data:

```
{
  "materialId": "80257017",
  "siteCode": "B341",
  "creationDate": "2017-05-09 03:23:45",
  "quantity": {
    "quantity": 50,
    "unitOfMeasure": "UNITOFMEASURE_CS"
  }
}
```

 On the right, there is a map of the United States with a green shaded area and several markers (green 'x', blue 'u', green 'v').

HOW MAS-BASED? WHAT'S VALID, WHAT CHANGED?



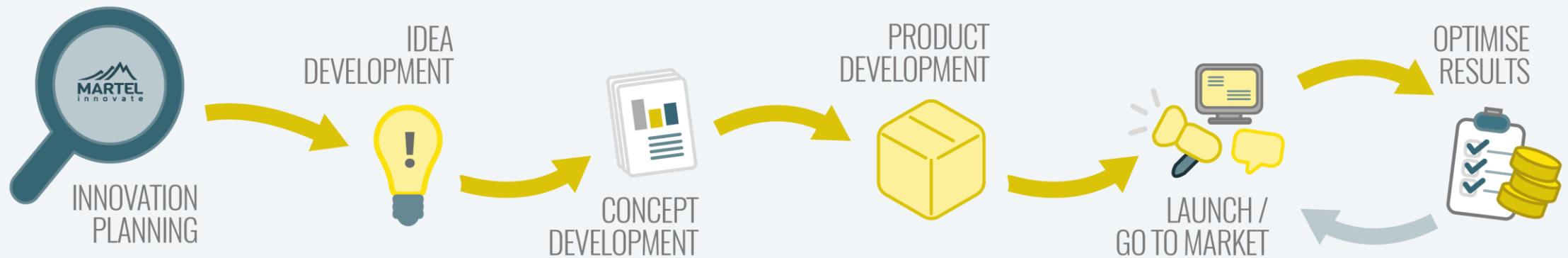
LSPS: Born in an AI winter, agent-oriented enough for 2016 revival

2019 ORCHESTRA CITIES

MARTEL'S VALUE PROPOSITION

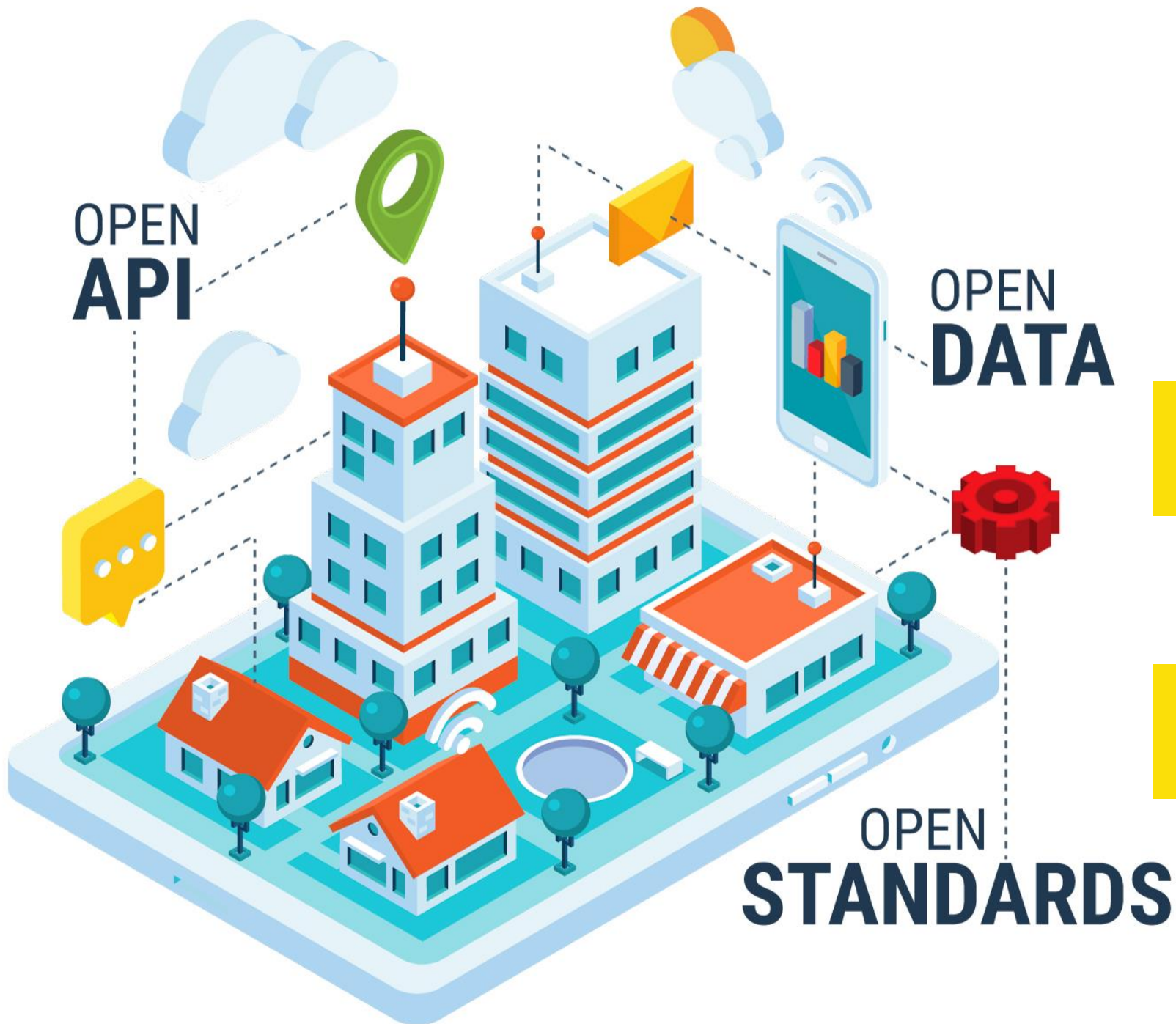


A comprehensive value driven approach supporting all innovation stages from idea to execution:



Martel's value proposition is delivered via our People, Know-how, Services, Technology, Processes and Partnerships

An agile combination of business, technology and media services lead by an international team of highly skilled and committed professionals



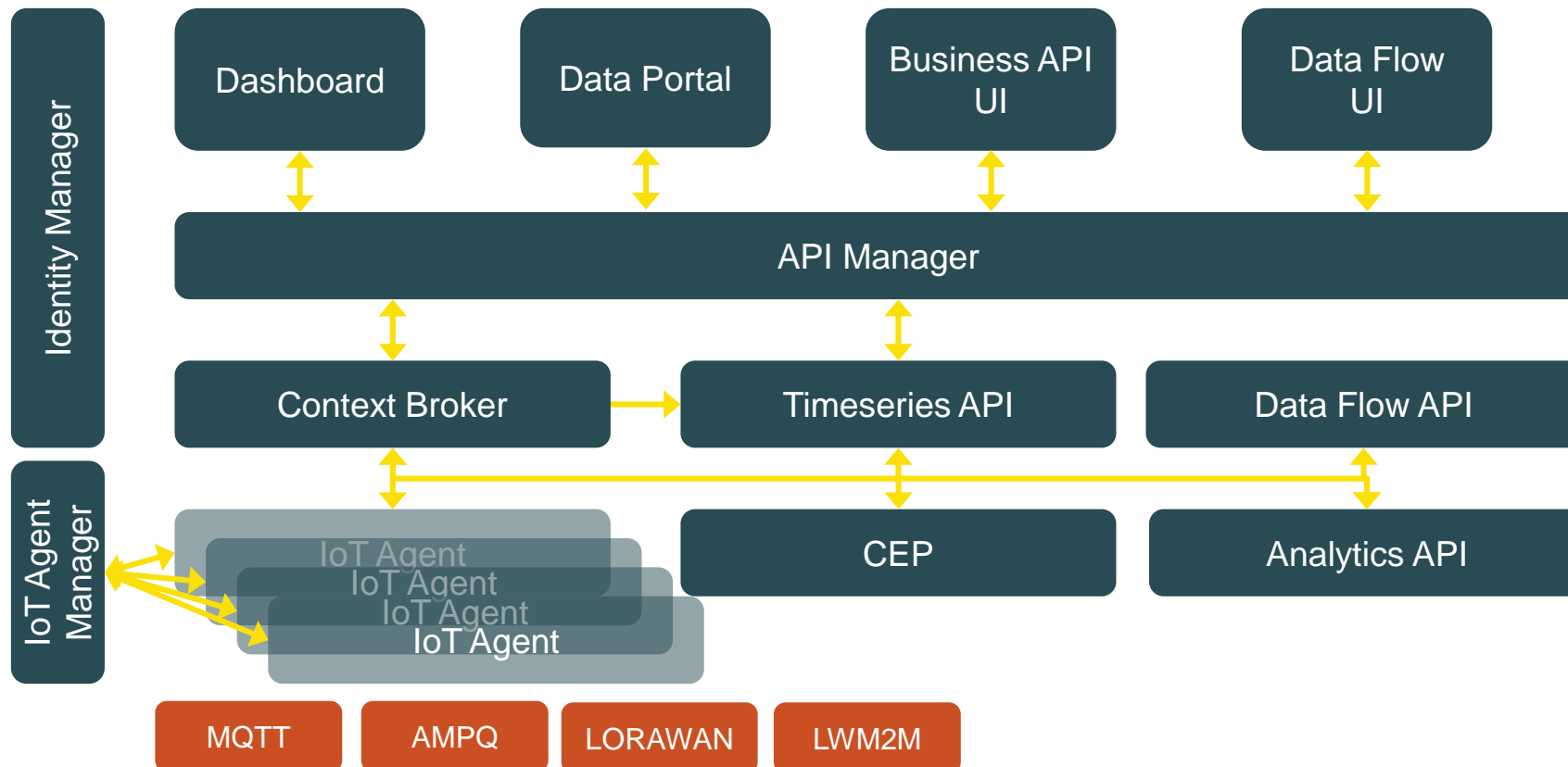
**CREATE AN
“OPEN”
PLATFORM**

REASONS FOR THE OPEN PLATFORM

To achieve these main objectives

- + A space where different cities can share data and services
- + Enable migrating data from vertical silos to a unified space
- + Ensure that city digital services will facilitate social inclusion
- + Let citizens and businesses in to the co-creation process

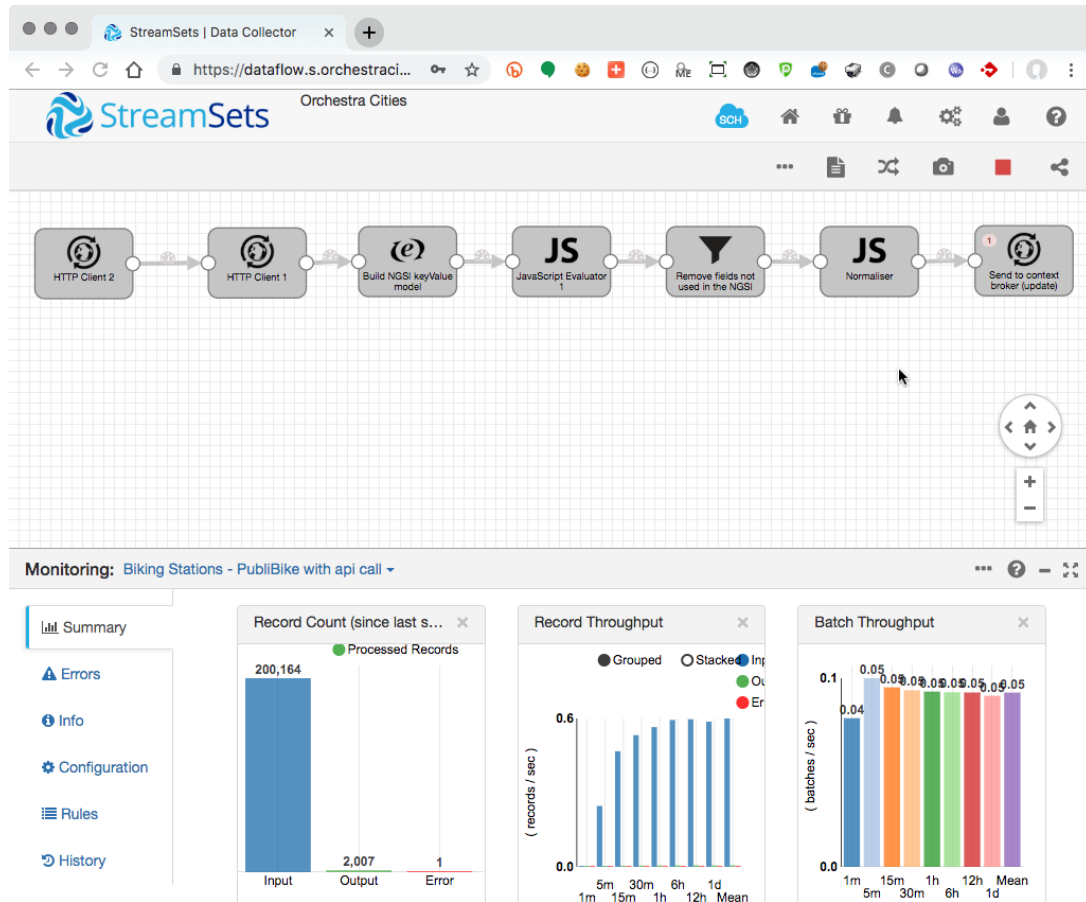
Cloud-native: microservices based, RESTful, multi-language



CORE TECHNOLOGIES AND SOURCES



TOOLS FOR DATA TRANSFORMATION



- **Manage visually different data import flows**
- **Transform data flows into configurable and sharable templates**

SITUATED DEMONSTRATION @ IOT-WEEK



Live Lego-based city model



Interaction shown in the Cloud



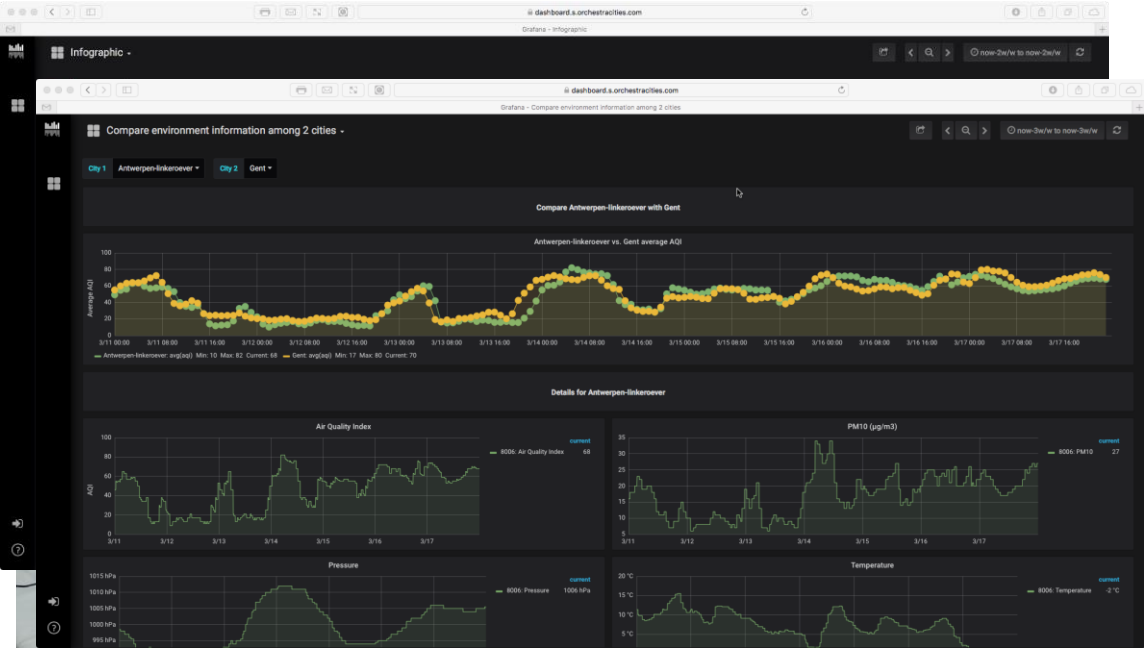
SITUATED DEMONSTRATION @ IOT-WEEK



Live Lego-based city model



Interaction shown in the Cloud



HOW MAS-BASED? WHAT'S VALID, WHAT CHANGED?



Orchestra Cities: from Cloud Computing, AI is on the roadmap

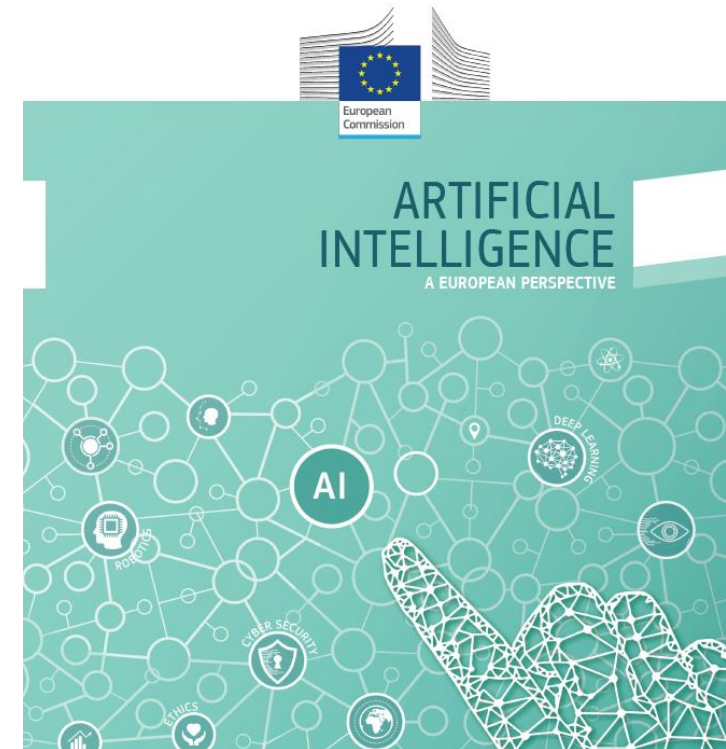
EUROPEAN AI

AI is now a Geopolitical Topic



AI Flagship Report (pub. 2018)

<https://ec.europa.eu/jrc/en/publication/eur-scientific-and-technical-research-reports/artificial-intelligence-european-perspective>



Ethical Guidelines

https://ec.europa.eu/newsroom/dae/document.cfm?doc_id=60419

- + The AI HLEG published it on April 2019
 - First chapter on Foundation
 - Second chapter on Implementation
 - Third Chapter on Assessment
- + Feedback received from the AI Alliance
- + Defines seven core requirements
- + Includes an assessment list for ***trustworthy AI***
- + Deep dives and trials about to start

Policy and Investment Recommendations

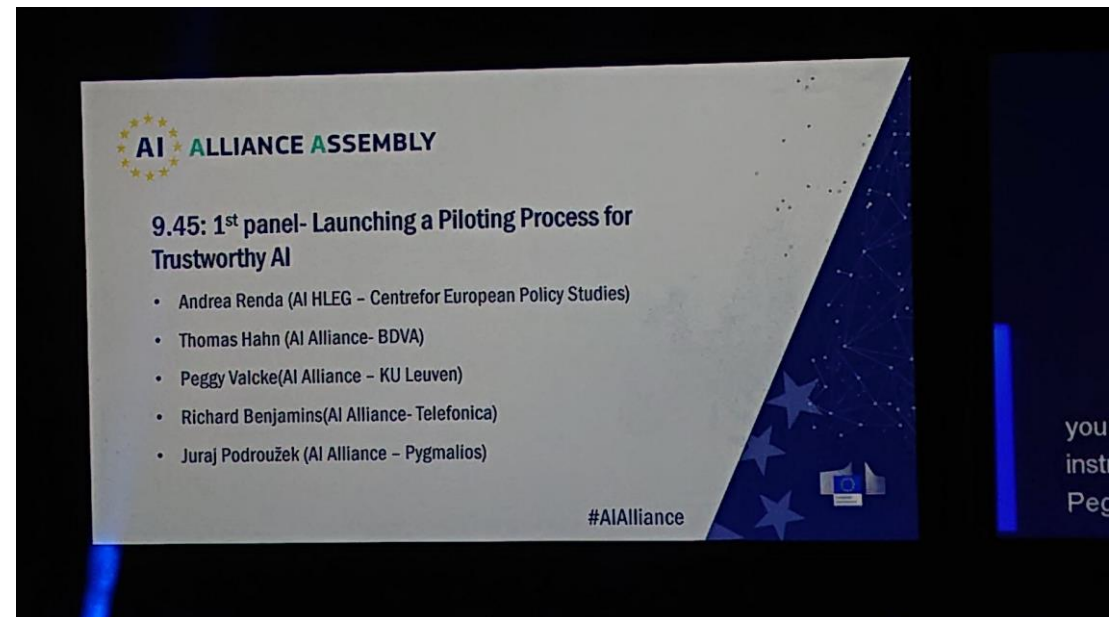
https://ec.europa.eu/newsroom/dae/document.cfm?doc_id=60343

- + Second deliverable from the AI HLEG
- + Adopting an holistic approach
 - All recommendations hang together
- + Includes 33 core recommendations
 - Exercise in distilling 300+ initial ones
- + Sums up content in 11 takeaway

Seven Major Requirements



Discussed in a Panel @AIAlliance



POLICY AND INVESTMENT RECOMMENDATIONS

Eleven Key Takeaways

Delivered 26.06.2019 @AIAlliance



THE WENET PROJECT

WENET FACTS AND FIGURES



HOME ABOUT WENET NEWS PILOTS OPEN CALL EVENTS RESOURCES CONTACTS



WELCOME TO WENET

A new way to empower
diversity-awareness
among people.

LEARN MORE

ABOUT US

Diversity is part of our everyday life. Technology, despite its evolution, still struggles when it comes to helping develop and maintain social relationships that transcend geographical and cultural backgrounds.

- + **WeNet – Internet of Us**
- + **Start Date: 1st January 2019**
Duration: 48 Months
Total budget: 6.5 M€
Coordinator: University of Trento
Prof. Fausto Giunchiglia
- + **Final outcome: An online platform that will empower machine mediated diversity-aware people interactions**
- + **Web site: <https://www.internetofus.eu/>**



AI



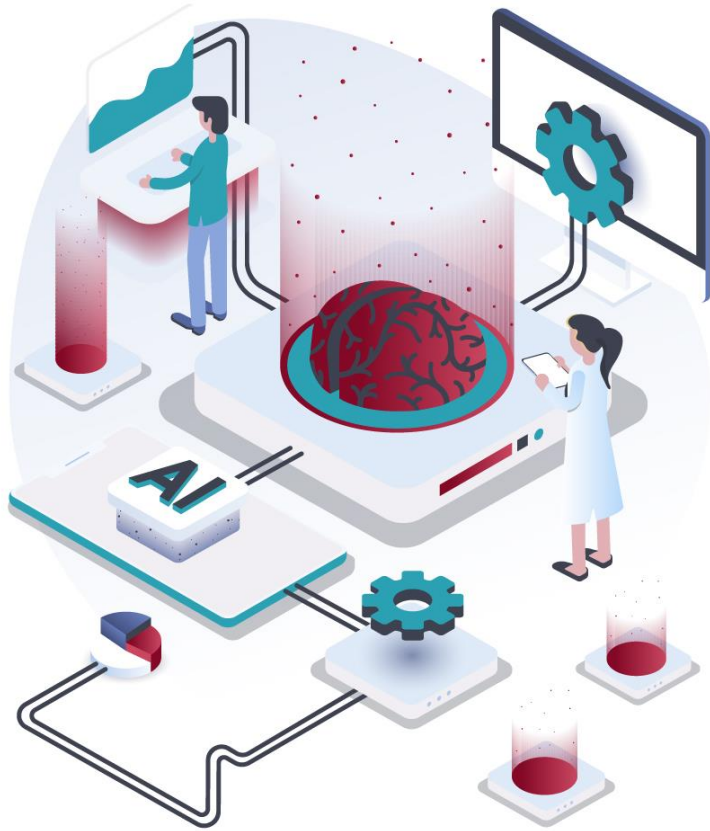
ETHICS



NETWORK

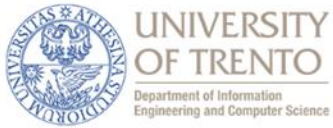
The main overall goal of WeNet is to develop the culture, science and engineering, methodologies, algorithms, social interaction protocols and an online platform which will empower machine mediated diversity-aware people interactions

WENET MAIN OBJECTIVES



1. Development of the scientific foundations, methodologies and algorithms empowering machine mediated diversity-aware people interactions.
2. Development of the WeNet online platform, integrating and consolidating the implementation of the methods and tools developed as part of Objective O.1
3. Large scale Smart University pilot trials in 18 different University and adult school sites and involve 10,000 participants.
4. Community building, which will expand from the consortium to all institutions worldwide
5. Ensure a clear ethical guidance for the technology development and the pilot activities

WENET CONSORTIUM





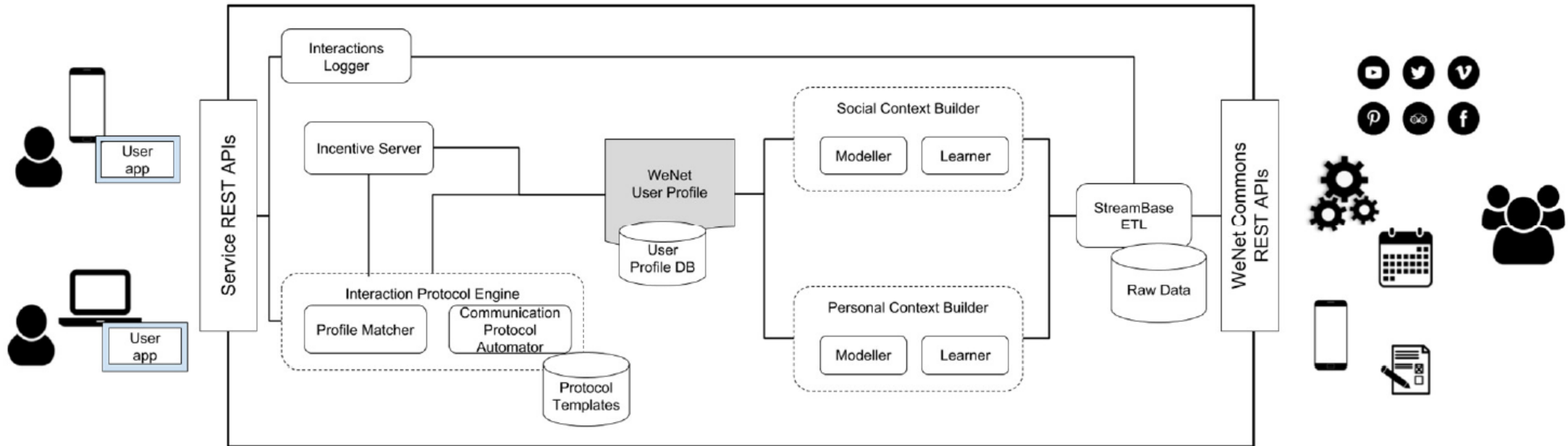
- + WeNet will run multiple pilot trials
 - 18 worldwide sites, including universities and adult school
 - 10,000 participants throughout the whole duration of the project
- + Pilots will run at:
 - August 2020 (*M20*)
 - December 2021 (*M36*)
 - August 2022 (*M44*).



- + The cascade funding system will be used to involve additional EU academic institutions interested in piloting with their own students the WeNet approaches, technologies and services.
- + Launch **May 2021 (M30)**

WENET PLATFORM ARCHITECTURE

The WeNet platform will implement and consolidate diversity-aware interaction protocols, learning algorithms and tools, based on a computational sociological theory of diversity under a clear ethical guidance



CONCLUSIONS

Some things fit just as well

- + Software component model
 - Autonomy of core components
 - Loose coupling with messages
 - Distribution and partial knowledge
- + Resource management
 - Containers and metadata
- + Maybe the greatest legacy
 - Collaborative human-machine vision
 - Interdisciplinarity is now mainstream

Much context has changed

- + Raising infrastructure abstraction
 - The VM is the appserver
 - OOP hit its (well known) limits
- + The language/library pendulum swung
 - Like in CORBA days!
 - Language design now streamlined
- + Symbolic AI second to ML/numeric one
 - Data drive the AI Renaissance



THANK YOU FOR YOUR ATTENTION

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