# Early Web Services Could Talk, But They Couldn't Understand Each Other.

Web Services held the promise of being self-contained, modular components for building intelligent, distributed software infrastructures.

However, the core limitation of early standards was their focus on *syntactic* capabilities. They defined the structure of communication, but not the *meaning* behind it.

Quote: "Current industry landscape provides only initial and very partial solutions to the ultimate problem... [standards] provide merely syntactical capabilities and do not fully cope with service semantics."

WSDL → Syntactic Connection → UDDI → Syntactic Connection → SOAP

The Semantic Gap
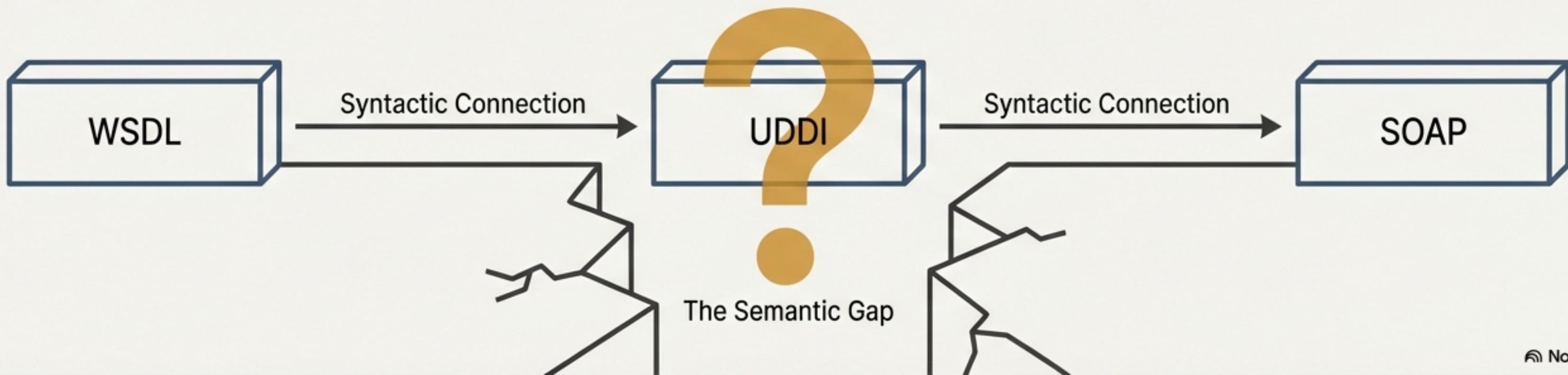
The Solution Is To Treat A Web Service As An Intelligent Agent's Capability

The central thesis: "The core of the methodology is the new understanding of a Semantic Web Service as a capability of an intelligent software agent supplied with the proper ontological description."

An intelligent agent brings proactive, goal-directed, and social abilities to the system—moving from passive components to active, reasoning participants.

Key Agent Attributes:
- Proactive & Goal-Directed
- Social (Coalition Formation, Negotiation)
- Rational (Utility Maximization)

BEFORE: Passive Component

Web Service

AFTER: Active Capability
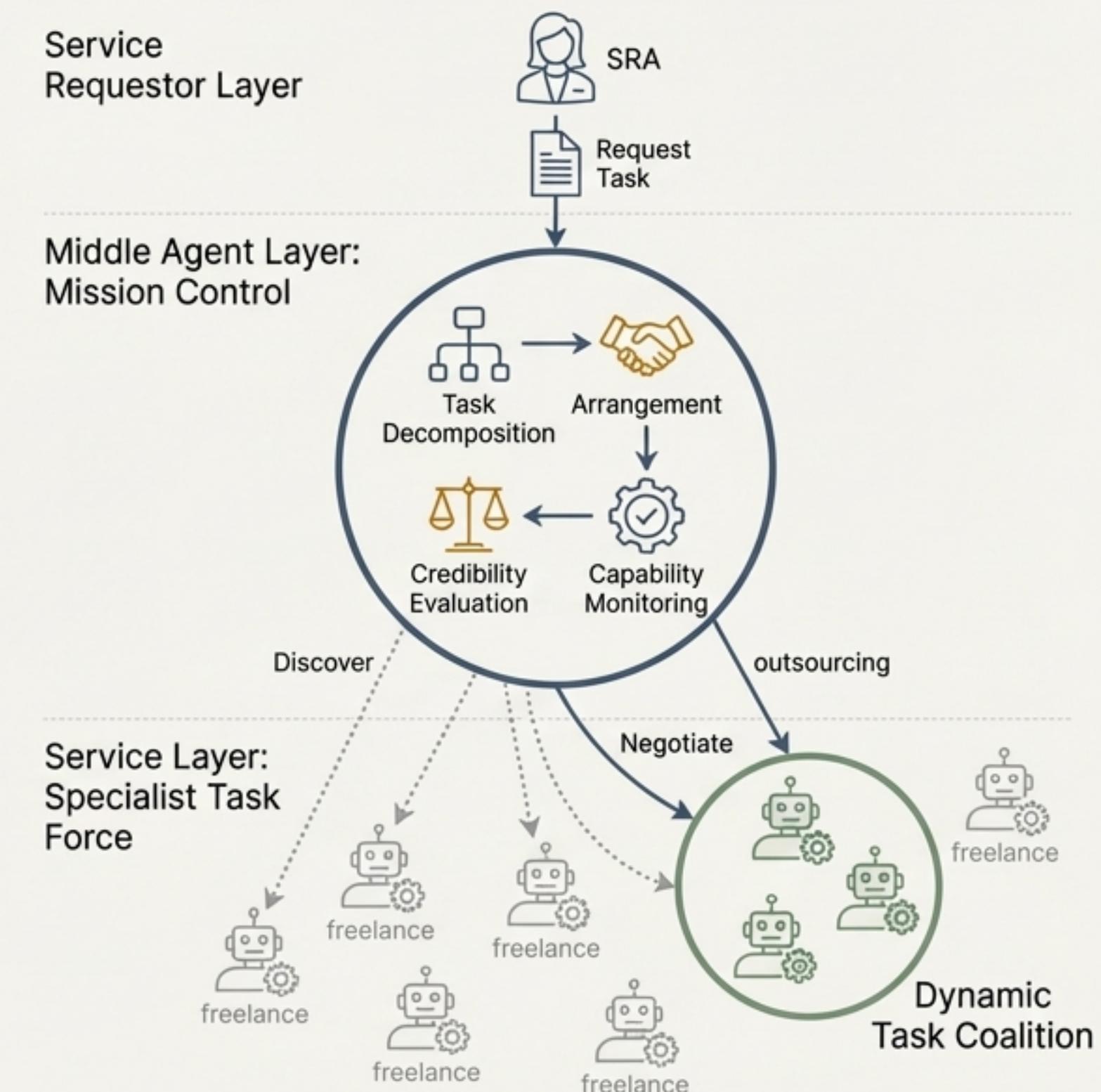
Capability

Intelligent Agent

A Middle Agent Layer Acts As Mission Control To Assemble Dynamic Service Coalitions

The architecture introduces an Agent Middle Layer between service consumers and providers.

Its function is to transform a high-level request into a task, decompose it, and orchestrate a dynamic coalition of specialized agents to execute it.

Key Principles:

- Composite services are interpreted as tasks.

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- The "mediator" is a temporary coalition of Service Providing Agents (SPAs).

- SPAs are autonomous and economically rational.

Service Requestor Layer — SRA — Request Task

Middle Agent Layer: Mission Control

Task Decomposition → Arrangement → Capability Monitoring → Credibility Evaluation

Discover · Negotiate · outsourcing

Service Layer: Specialist Task Force

freelance, freelance, freelance, freelance, freelance, freelance, freelance

Dynamic Task Coalition

NotebookLM

The 'BookRoundtrip' Scenario Illustrates Dynamic Composition in Action.

To make the framework concrete, we follow a complex travel request for a conference. A Service Requestor Agent (AUTHOR) hires a Travel Agent to coordinate multiple specialists.

Mission Task Force

AUTHOR (A): The Service Requestor

TRAVEL AGENT (T): Middle Layer Contractor

FARE AGENT (F): Airfare Specialist

HOTEL AGENT (H): Accommodation Specialist
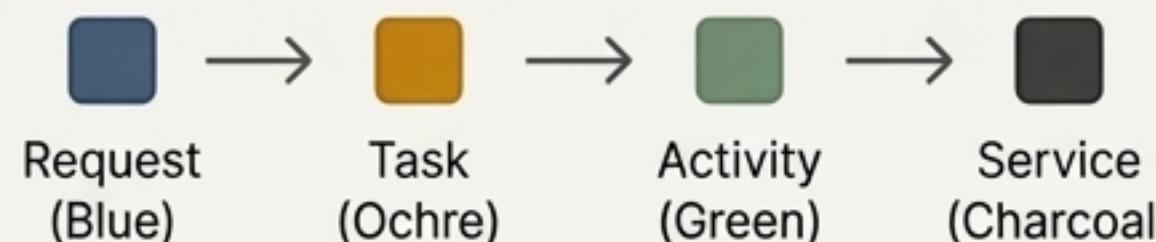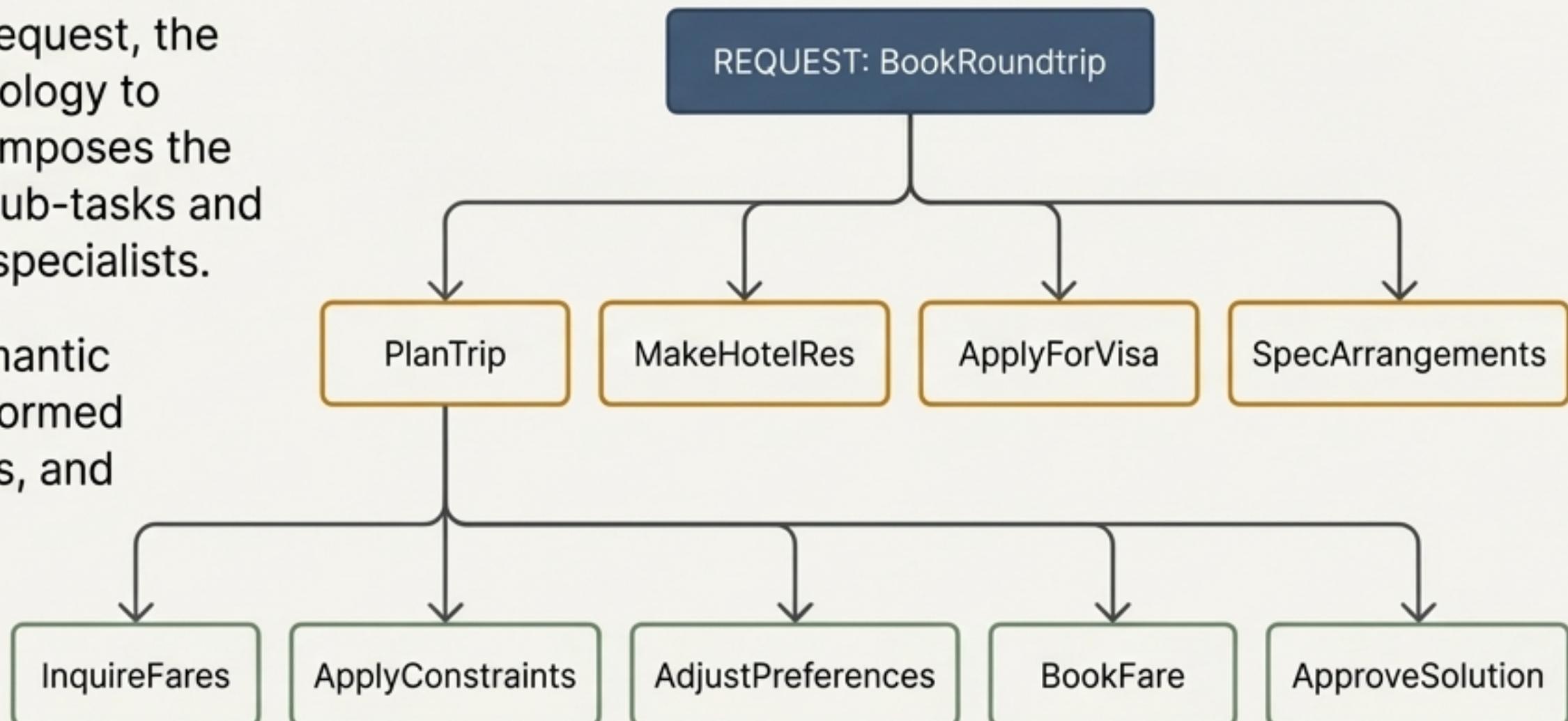
ICWS INFO (I): Event Information Specialist

Mission Brief: BookRoundtrip

Core Request
```
BookRoundtrip(
    Starting_Point="Kiev",
    Destination="Erfurt",
    Beg_Date="22/09/2003",
    End_Date="25/09/2003"
)
```

Preferences
```
Preferences=(
    "low fare",
    "fast connections",
    "4-star hotel"
)
```

Constraints
```
Constraints=(
    Budget = €1500,
    Payment=(VISA, USD),
    Hotel >= 3-star
)
```

The Travel Agent Decomposes The Mission Into A Hierarchy Of Coordinated Tasks.
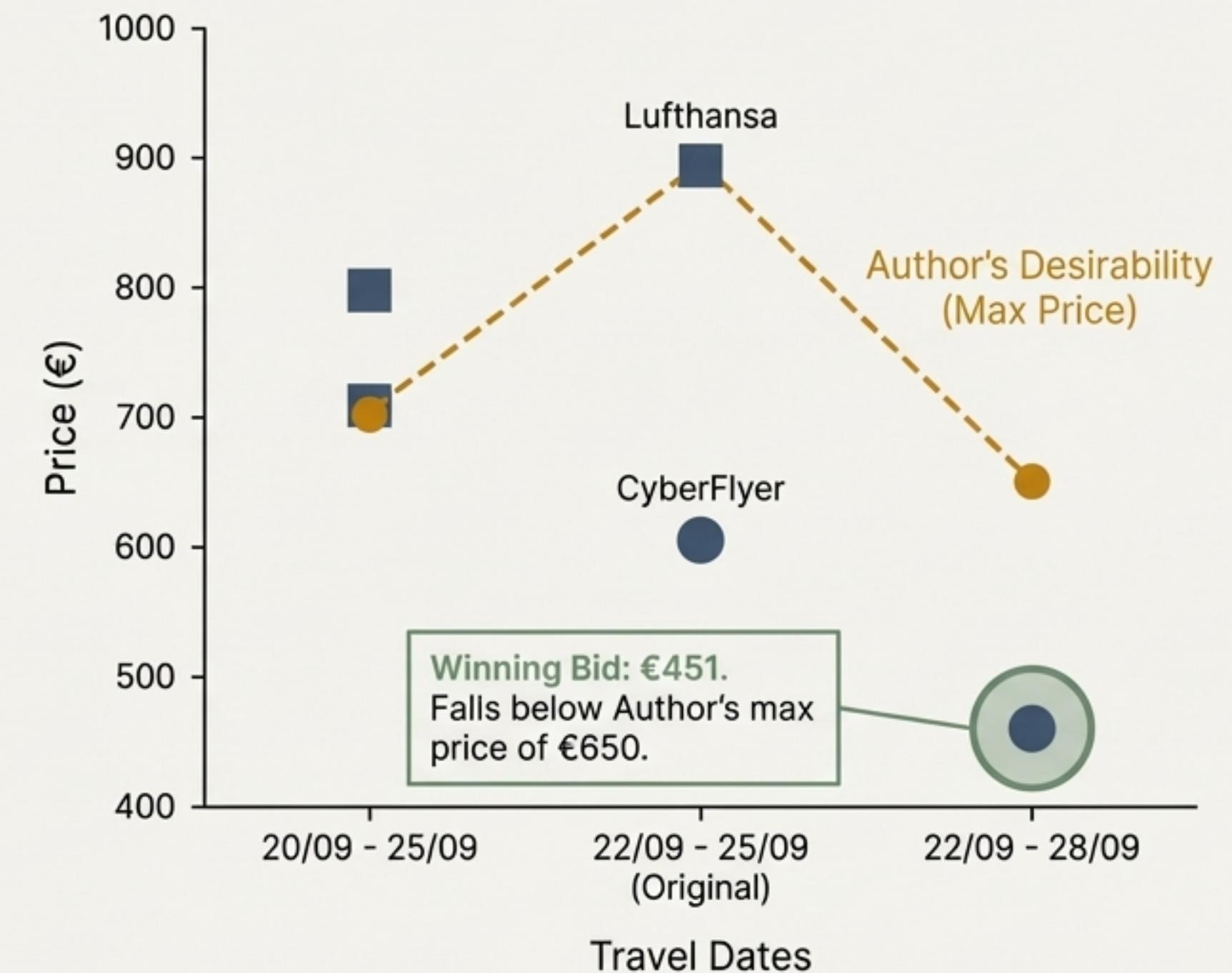
Upon receiving the `BookRoundtrip` request, the Travel Agent uses its internal Task Ontology to recognize it as a complex task. It decomposes the high-level request into a hierarchy of sub-tasks and activities, which are then allocated to specialists.

This demonstrates the principle of semantic **layering**: a high-level Request is transformed into a **Task**, decomposed into Activities, and fulfilled by concrete Services.

REQUEST: BookRoundtrip

- PlanTrip
- MakeHotelRes
- ApplyForVisa
- SpecArrangements

- InquireFares
- ApplyConstraints
- AdjustPreferences
- BookFare
- ApproveSolution

Request (Blue) → Task (Ochre) → Activity (Green) → Service (Charcoal)

NotebookLM

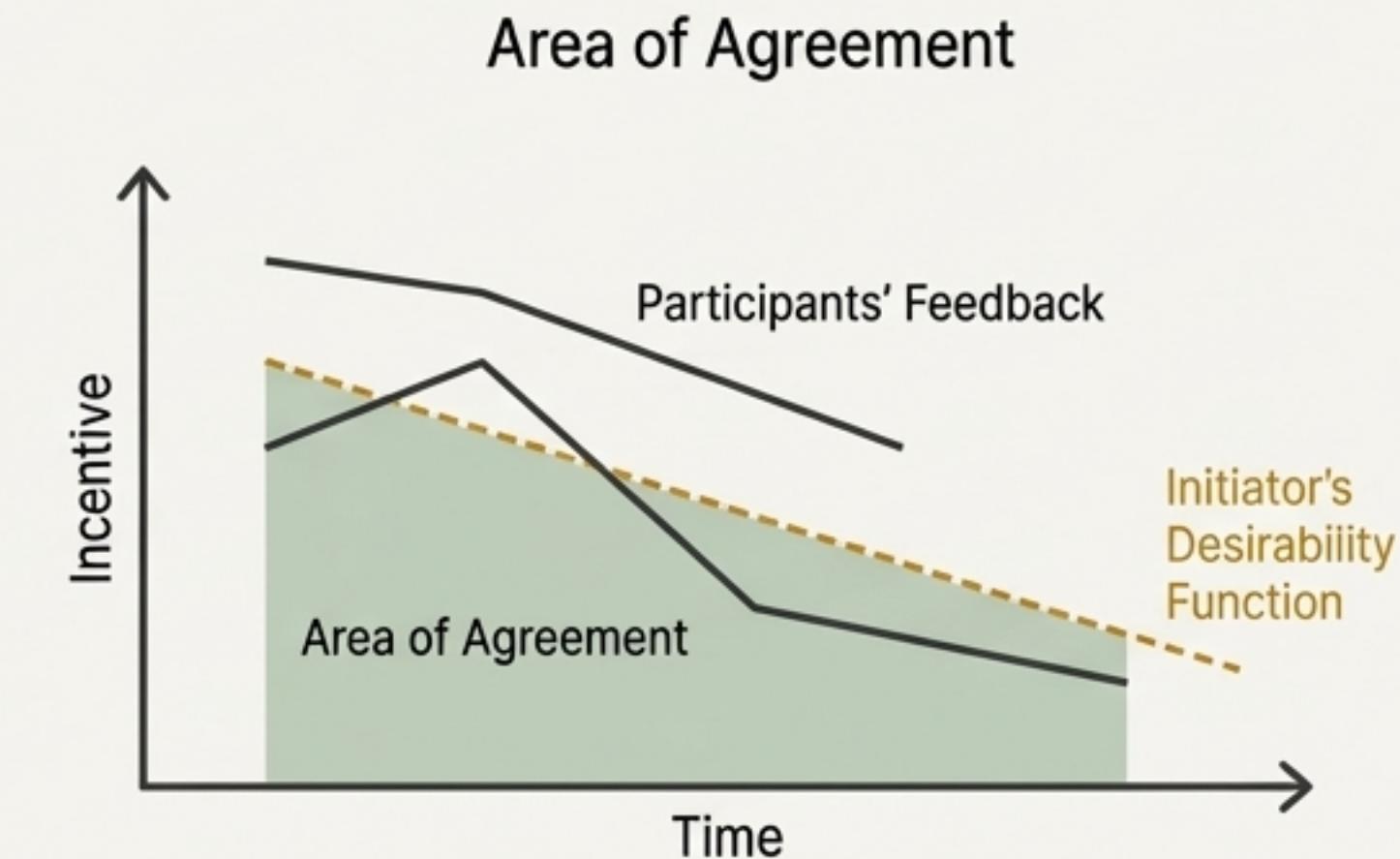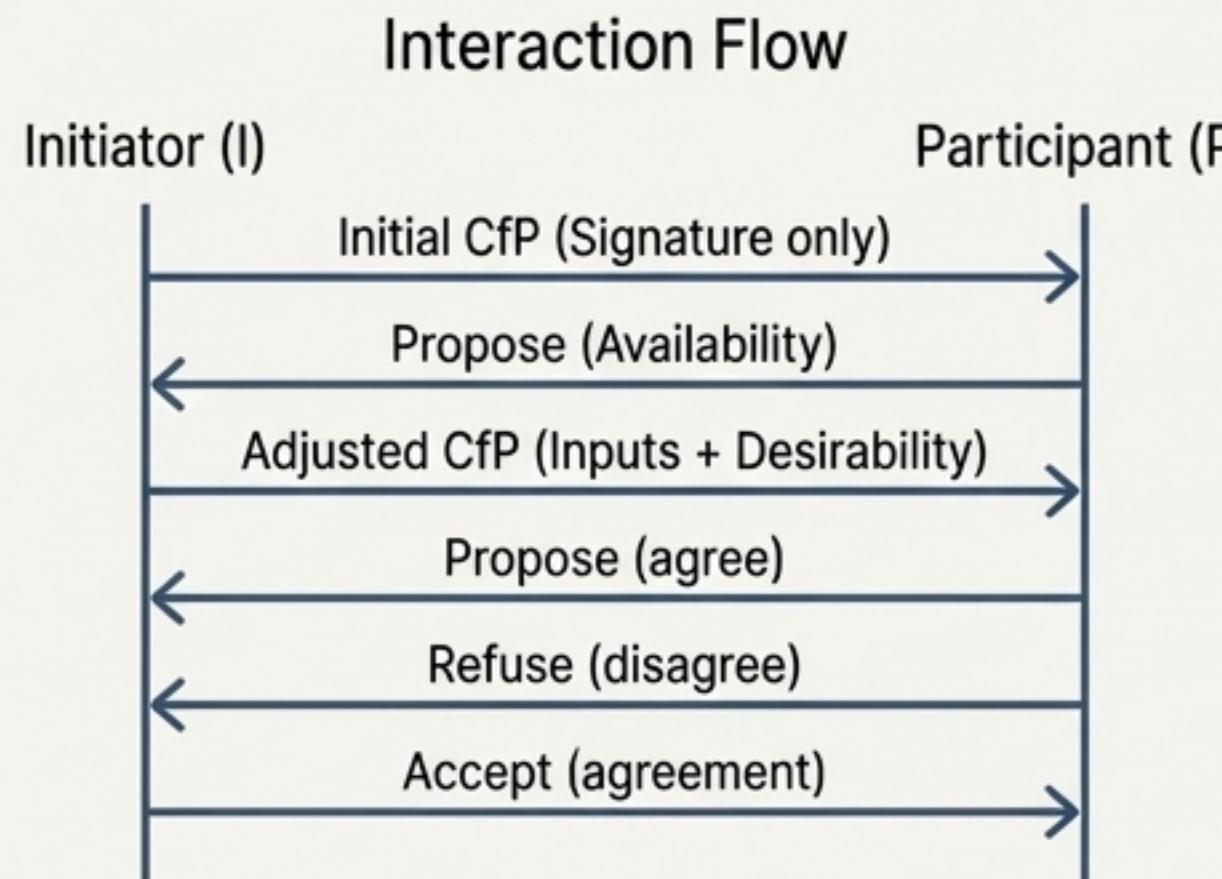# Agents Proactively Negotiate Inputs to Achieve Better Outcomes

- Knowing the "Sunday Rule" for airfare discounts, the Travel Agent proactively suggests alternate dates to the Author agent.

- It negotiates these options, receiving desirability values (max price) for each date range.

- It then initiates a Contract Net negotiation with multiple Fare Agents for all three date options to find the optimal solution.

Scatter/line chart with y-axis "Price (€)" ranging from 400 to 1000, and x-axis "Travel Dates" with categories "20/09 – 25/09", "22/09 – 25/09 (Original)", "22/09 – 28/09". Labels include "Lufthansa", "CyberFlyer", "Author's Desirability (Max Price)", and a box reading "Winning Bid: €451. Falls below Author's max price of €650."

NotebookLM

The Extended Contract Net Protocol Formalizes Multi-Round Negotiations.

Activity allocation is managed by an extension of the FIPA Iterated Contract Net protocol, allowing for multi-round negotiation.

- Round 1: Initiator sends a Call for Proposal (CfP) with only the activity signature to find capable Participants.
- Round 2+: Initiator sends an adjusted CfP with specific inputs and a 'desirability function'. Participants respond with proposals, counter-offers, or refusals.
- The process continues until an agreement is reached or options are exhausted.

Interaction Flow

Initiator (I) — Participant (P)

- Initial CfP (Signature only)
- Propose (Availability)
- Adjusted CfP (Inputs + Desirability)
- Propose (agree)
- Refuse (disagree)
- Accept (agreement)

Area of Agreement

Incentive / Time

Participants' Feedback

Initiator's Desirability Function

Area of Agreement

Agents Continuously Assess Each Other's Capability and Credibility

Capability Assessment

- Agents maintain a 'Fellows' Capability Expectations Matrix' (FCEM) based on past negotiations, allowing them to contact known partners directly.
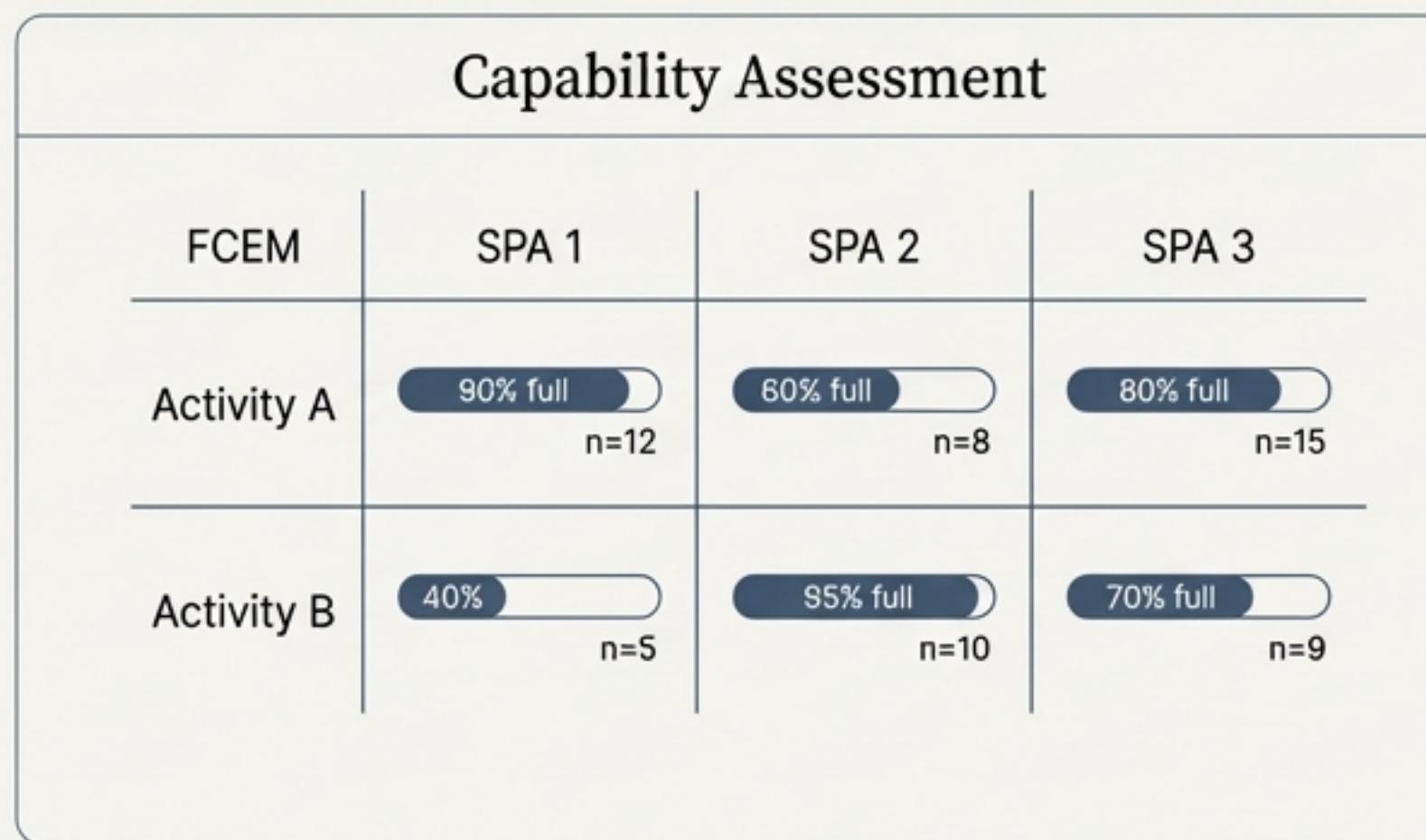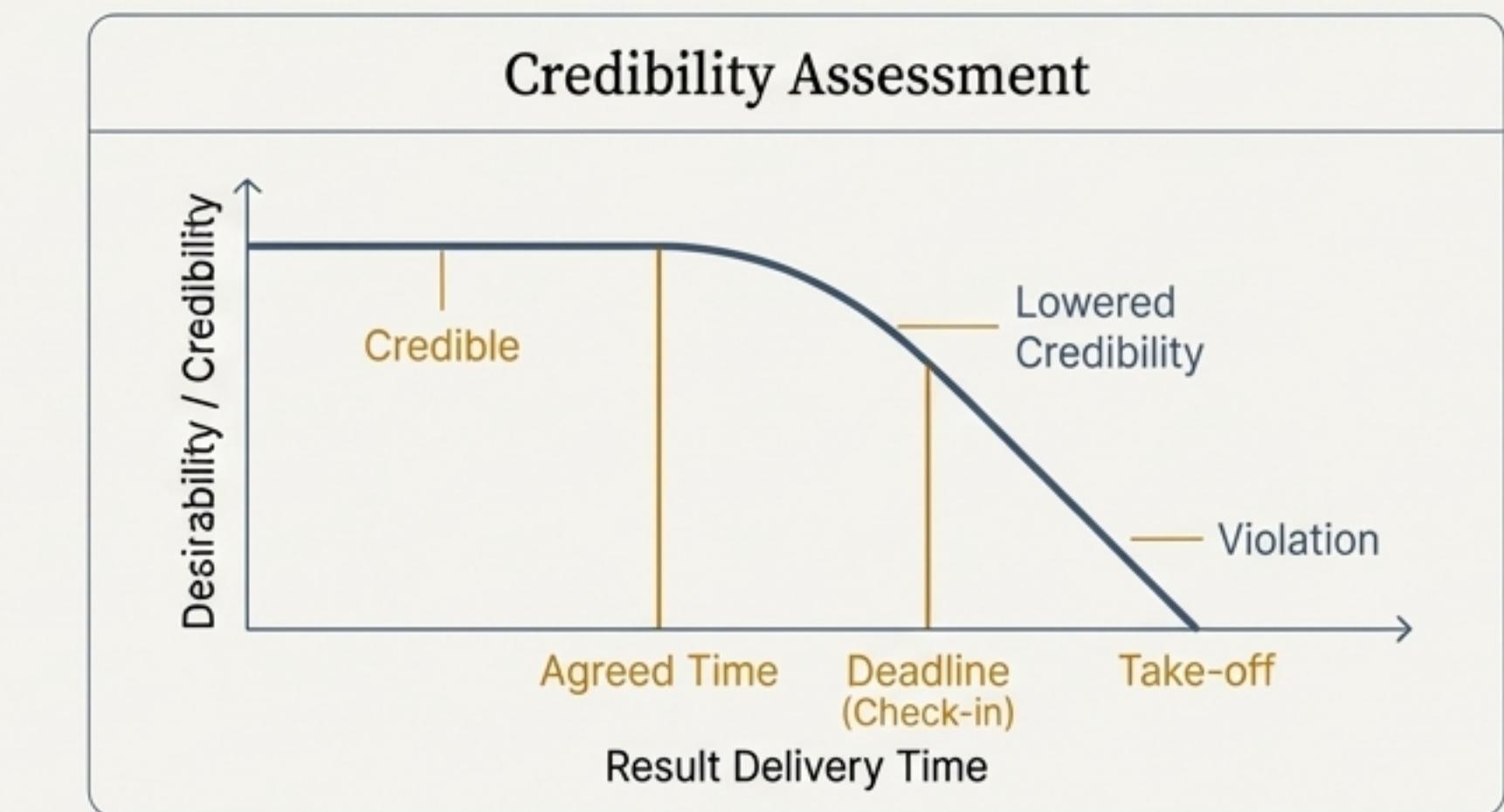
Credibility Assessment

- Credibility is measured by performance against commitments. The desirability of a result decreases sharply if delivered late.

Example: `DeliverAirTickets`:

- On Time (agreed 30 mins before check-in): Credibility maintained.
- Late (5 mins before check-in): SRA is 'aggrieved,' SPA's credibility lowered.
- Very Late (after check-in opens): Serious violation, credibility 'drastically lowered."

Capability Assessment

FCEM	SPA 1	SPA 2	SPA 3
Activity A	90% full n=12	60% full n=8	80% full n=15
Activity B	40% n=5	95% full n=10	70% full n=9

Credibility Assessment

Desirability / Credibility vs Result Delivery Time

Credible — Lowered Credibility — Violation

Agreed Time — Deadline (Check-in) — Take-off

Impact I: The RACING Project Applies The Framework To Intelligent Information Retrieval

- In the RACING project, a user query is treated as a service request, and distributed documents are the resources.

1. A User Agent (UA) submits a keyword query.

2. A Query Transformation Agent (QTA) converts it to a semantic query using an ontology.

3. A Query Planning Agent (QPA) decomposes the semantic query.

4. The QPA negotiates with Resource Wrapper Agents (RWAs) to execute partial queries.

5. Results are merged and returned.
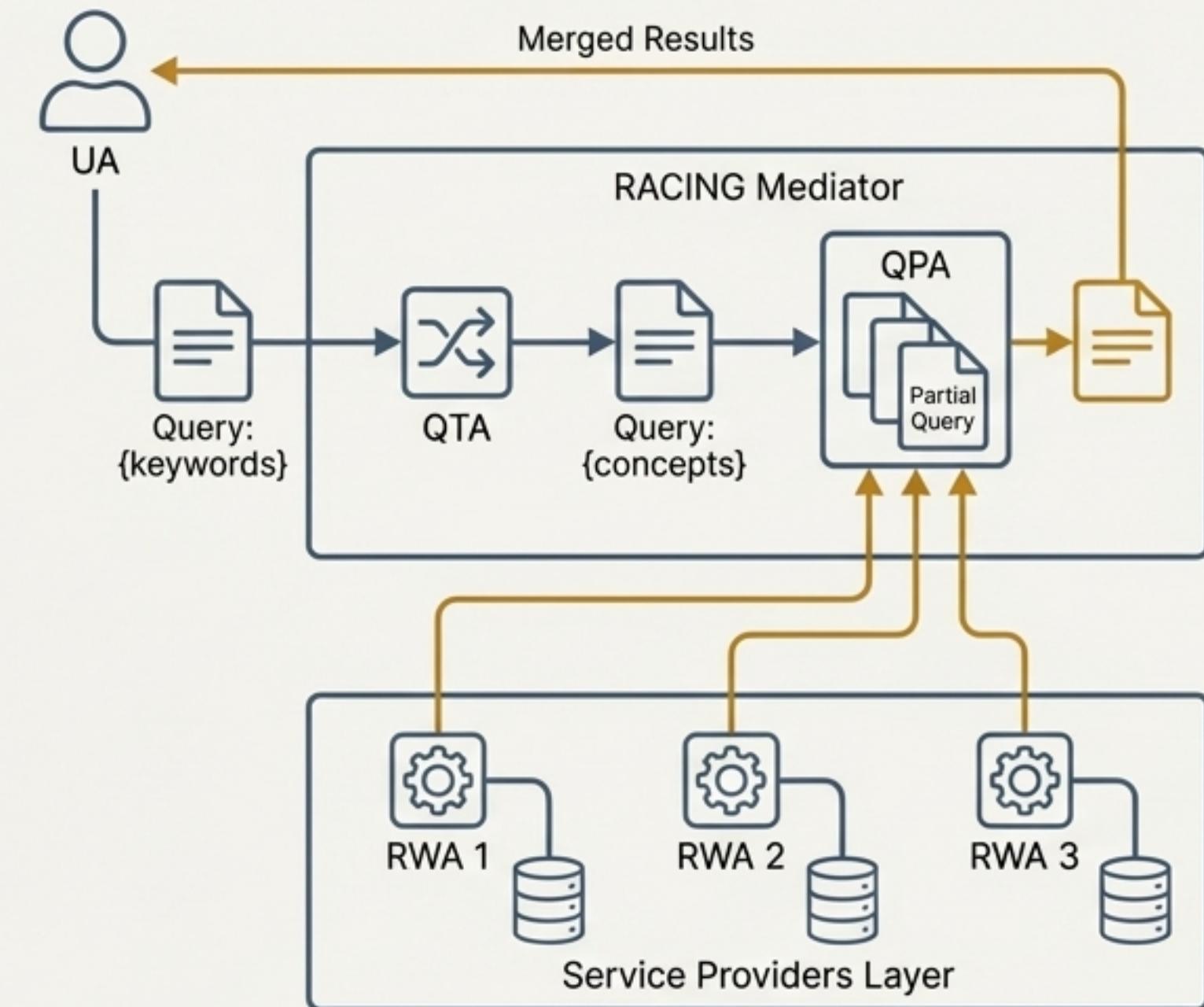
Impact II: OntoServ.Net Deploys Mobile Agent Services In A P2P Industrial Network

The framework extends to managing complex industrial machinery (e.g., a paper mill) in a peer-to-peer network, introducing new challenges and capabilities.

- **Fully Decentralized**: No central mediator. Platform-manager agents at each node handle composition.
- **Service Mobility**: Services are wrapped by mobile agents that migrate to the machine's local platform, minimizing network traffic for long-term monitoring.
- **Dual Roles**: Resource Wrapping Agents (RWAs) act as both service providers and requestors.
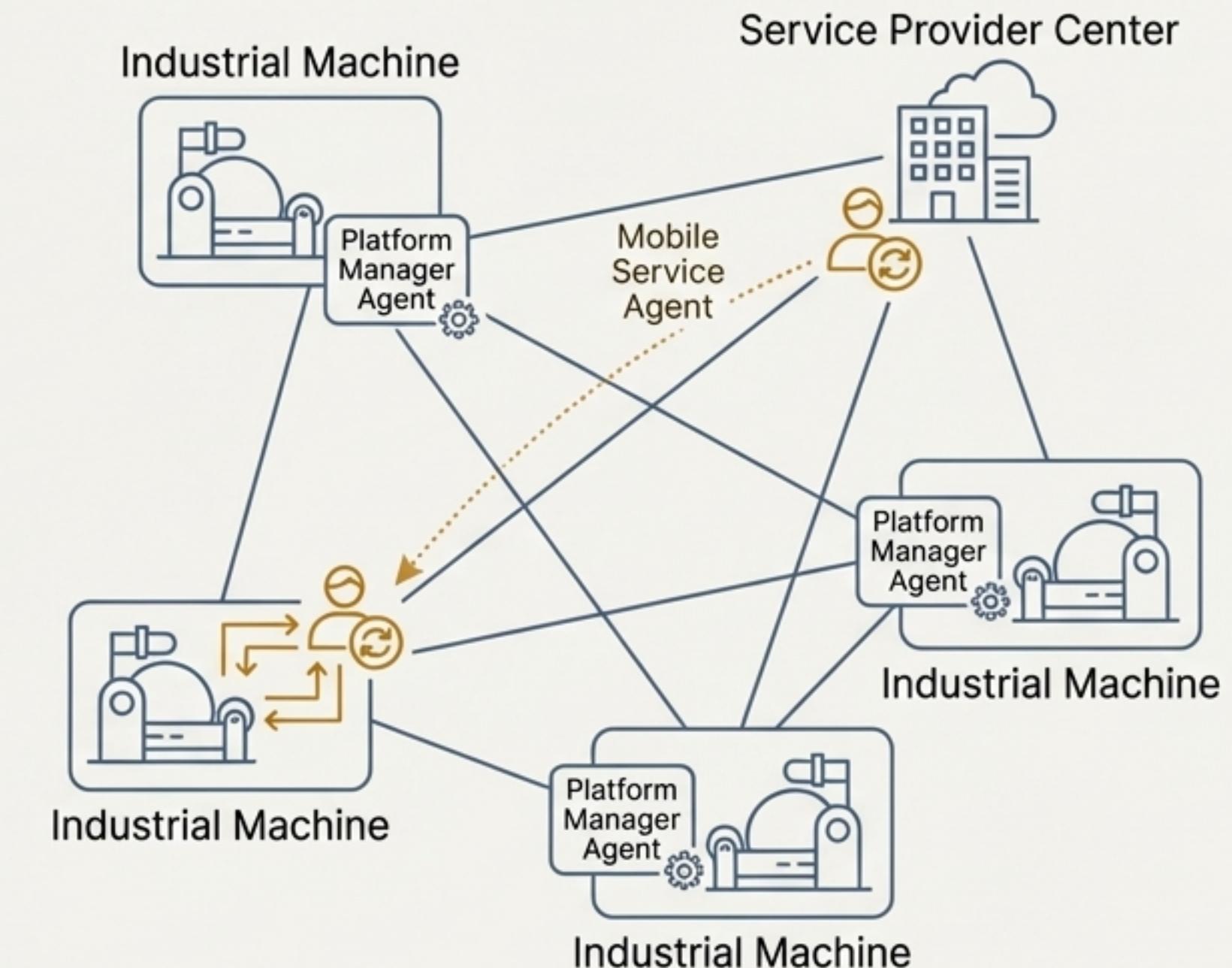
The Ultimate Vision Is A Global Understanding Environment of Proactive, Cooperating Resources.

The core contribution is an agent-based framework where dynamic coalitions of rational agents compose services to perform complex tasks.

This is a foundational step toward a "Global Understanding Environment" (GUN), where heterogeneous resources become web-accessible, proactive, and cooperative.

Resources can automatically monitor their state, diagnose problems, and order maintenance services from other resources on the network.

Enabled by the synergy of three fundamentals:
- Interoperability (Semantic Web)
- Automation (Agent Technology)
- Integration (Multi-agent coordination)

Global Understanding Environment