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BRIEF
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Adaptive Agents Boost Supply Network Flexibility

As manufacturers migrate to adaptive supply networks, they will exploit intelligent-agent technology to detect and resolve operational glitches proactively. Who will benefit most? Decentralized organizations with a partner-friendly mindset.

Over the next decade, Forrester expects the self-regulating capabilities of long-standing energy and telecom transmission networks like SONET to extend to manufacturing supply chains, paving the way for adaptive supply networks (see the February 22, 2002 Forrester Brief "Executive Overview: Adaptive Supply Networks").

In these sense-and-respond networks, manufacturers will need to make operational decisions on the fly and in close collaboration with partners. Unfortunately, current batch-oriented planning apps and backward-facing analytic tools won't help. To enable collaborative problem solving and distributed decision-making within adaptive supply networks, Forrester expects a new breed of real-time decision-support software to arise, called adaptive agents. They are defined as (see Figure 1-1):

> *Configurable, distributed software components that continually realign disparate goals and processes.*

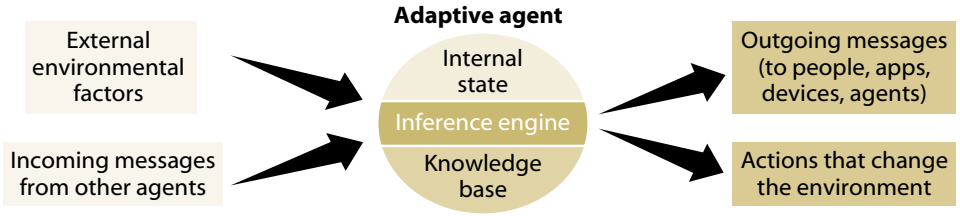
Adaptive agents don't operate in isolation; they are coordinating actions constantly with other agents, forming multiagent systems (see Figure 1-2). These systems will increase supply networks' adaptability by offering four classes of specialized services:

1) **Analysis agents will interpret data in real time.** Analysis agents will use fuzzy logic to sift through the enormous data streams generated from Web-service-enabled business apps and sensor-embedded physical assets, looking for meaningful information to pass to other agents. If their data analysis points to a pending outage or an out-of-bound deviation in a cross-enterprise process, these agents will notify immediately all nodes that could be impacted.

Figure 1 Cooperating Adaptive Agents Will Boost Supply Networks' Adaptability

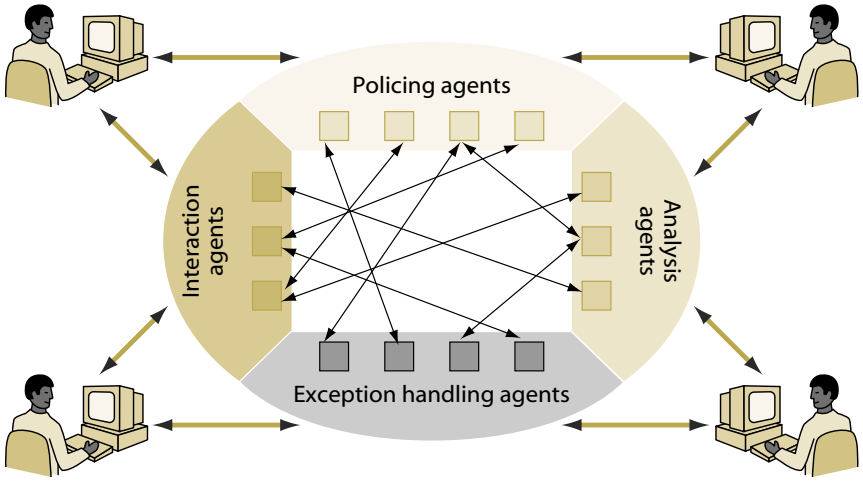
A spreadsheet is available by clicking the online "Get Data" button above this figure

1-1 Adaptive agents and their properties



Property	Description
Cooperation ability	An agent can use signals to convey interest or info to other agents in its environment. Agents may work toward a single global goal or separate individual goals.
Autonomy	Agents should operate without the intervention of external elements (e.g., other agents or humans). They have some control over their actions and internal states.
Reactivity	Agents can perceive their environment and respond to changes in a timely fashion.
Adaptability	Agents can set up goals based on implicit interests.
Granularity degrees	Reactive agents lack intelligence about their behavior. But intelligent adaptive agents know their environment and can act on themselves and on the environment.
Learning	Either the multiagent system itself can learn (as a network) or each individual agent may be embedded with a learning algorithm (e.g., neural network).
Proactivity	Agents should exhibit goal-directed behavior such that their actions cause beneficial changes to the environment.

1-2 Interactions within a multiagent system can be monitored constantly by users



Source: Forrester Research, Inc.

2) **Exception-handling agents will resolve glitches.** Residing at individual nodes across the network, these agents will be notified of a developing exception. Through analyzing the bottleneck in real time, they will recommend the best course of action and redirect tasks to match the needs of their owner -- by taking into account both local constraints as well as shared global objectives.

3) **Interaction agents will regulate access and security.** As the watchdogs of interaction rules, they will ensure that other agents can access only the partner data they are allowed to and can interact only with agents they are allowed to collaborate with. This function is critical to facilitate agent-based interactions across firewalls, so a supplier can be sure that only its most trusted partners' agents can access its data.

4) **Policing agents will coordinate the network.** To manage the activities of potentially competing or cooperating node-level agents, these agents will ensure that the constant pursuit of self-interest among individual nodes doesn't compromise the entire network's equilibrium -- for example, when several production lines or factories in a network are vying to produce the same product or use the same resource.

Adaptive Agents Are In Action Today At Global 3,500 Companies

Intelligent-agent technology has been the center of academic research for decades -- and the US military has built several useful applications around it. But in the last three years, leading Global 3,500 companies have begun to exploit agent-based tools to improve the performance of supply chain activities dramatically.

- **eProcurement (Deutsche Post).** Using living systems' agent platform, Deutsche Post (DP) has built PORTIVAS, a private hub that optimizes DP's trucking service procurement needs -- worth $1.7 billion. PORTIVAS' spot-market engine uses agent technology to automatically match multiple attributes, such as weight, dimensions, origin, and destination, of each piece of freight against offerings of 6,000 German carriers. In a later phase, PORTIVAS will also use agents for multinode capacity optimization. DP invested $3.4 million in startup costs, but it expects to achieve $17.4 million in annual savings starting in 2002.

- **Manufacturing (DaimlerChrysler).** DaimlerChrysler piloted a multiagent system in 1999 in its Stuttgart-Untertürkheim factory, which makes cylinder heads via a 60-stage production process. In the multiagent system, coordination was achieved by modeling every machine, every work order, and every set of points in the plant's transport system as an agent. Like an auction system, the work orders offer themselves to the highest-bidding machines -- the ones with the most available capacity. Due to the success of the pilot, DaimlerChrysler expects the use of adaptive-agent technology to increase its Stuttgart plant's productivity by 10%.

- **Order fulfillment (Procter & Gamble).** To improve inventory management, Procter & Gamble (P&G) used BiosGroup's app to build an agent-based model of its fulfillment network, encoding the actual planning, sourcing, production, and delivery policies employed by the different nodes. The model's counterintuitive discovery was that sending less-than-full truckloads and combining multiple stock-keeping units in each truckload shipment would actually speed the flow of products through its network, curbing stock-outs and slashing inventory by 30%. P&G is now preparing to roll out the agent-recommended policy enterprisewide -- and is working on internal organizational changes needed to make it effective.
- **Transportation (Southwest Airlines).** Looking to fix severe cargo-handling bottlenecks, Southwest Airlines developed an agent-based model to simulate destinations, freight-house operations, and its ramp personnel. The model revealed that freight handlers offloaded and stored many packages unnecessarily, ignoring a plane's ultimate destination. To avoid the ensuing logjams, agents suggested a "same plane" routing strategy: Instead of shuffling parcels like hot potatoes onto the most direct flights, handlers must simply leave them onboard to fly more circuitous routes. After implementing the new rules in 2000, Southwest cut overnight transfer weight by 71% and saved $10 million in labor costs.

To Cross Company Firewalls, Adaptive Agents Will Exploit Emerging Technologies

Most early adopters have deployed multiagent systems within their four walls. But the real promise held by adaptive agent technology is to streamline coordination *across* entire supply networks -- by continually seeking alignment between multitier partners' incongruent goals and processes. Such cross-firm deployment scenarios will become more common circa 2004, when adaptive agents begin exploiting emerging technologies like:

- **Web services -- to synchronize multifirm processes.** Web services are emerging rapidly as a low-cost, system-to-system integration mechanism. We expect agents to use Web-services-standard-based registries and workflow to discover other agents and resolve intercompany process exceptions (see the December 2001 Forrester Report "Start Using Web Services Now"). For instance, if Eastman Chemical Company's agents detect a looming storm that will disrupt delivery of feedstock from Mexico, they can query Eastman's own registry for a precertified alternate supplier closer to home.
- **Extended Internet -- to track physical-asset status.** In the semiconductor industry, equipment downtime costs $100,000 an hour in lost revenues. But agents that monitor operational conditions like temperature in TSMC's foundry can flag exceptions as soon as out-of-bound conditions emerge. For instance, if the filter in an HVAC system is about to wear out, TSMC's agents can sync up with Carrier's

agents to recalibrate production for the installation of a replacement filter (see the October 2001 Forrester Report "The X Internet Invigorates B2B Apps").

- **Hosted data dictionaries -- to enable knowledge sharing among partners.** Web service protocols like SOAP and WSDL only standardize the *envelope* and the *alphabet* of messages being exchanged between partners. But without access to vocabularies, agents won't be able to interpret correctly the *meaning* of data that firms exchange. Forrester believes that emerging standards like RDF and OIL will let firms codify unstructured information like objectives and constraints in the form of hosted data dictionaries -- ontologies -- for use by partners' agents (see the December 2001 Forrester Report "How The X Internet Will Communicate").

HOW WILL ADAPTIVE AGENTS WORK IN THE REAL WORLD?

Most adaptive-agent technologies have yet to emerge from standards committees or vendors' research labs. But some aggressive Global 3,500 users will quickly realize their potential. We expect these early adopters to share two complementary characteristics:

1) **Cooperative attitude toward partners.** Adaptive agents perform best and learn faster within networks where firms share relevant data willingly with partners that need it. But a high-tech OEM that deploys agents within its outsourced supply network won't be able to purge inventory gluts if it is unwilling to communicate regularly with its contract manufacturers' changes in demand signals. We expect cooperative-minded firms like Ericsson, which updates suppliers every 15 minutes on demand changes, to be well-positioned to use adaptive agents to maximize networkwide performance.

2) **Decentralized decision-making structure.** Adaptive agents can help a channel master expedite the resolution of its supply net exceptions -- only if it is willing to delegate problem-solving authority to its partners. But firms with a centralized decision-making structure -- that dictate *what to do* to partners as opposed to telling them *how to be* -- will fail to exploit the self-regulating capabilities of multiagent systems. We expect firms like Toyota and Unilever, with track records of decentralized supply network execution, to make the most out of the bottom-up control mechanism featured in multiagent systems.