The slides that follow attempt to explain how my interests in Remote Robotics and Supervised Autonomy have Converged to Focus on Key Challenges to "Massive IIoT" and Authenticated Edge Intelligence.

Introduction to Book Rethinking the Internet of Things, Intel Press, 2013.

I didn't set out to develop a new architecture for the Internet of Things (IoT).

Rather, I was thinking about the implications of control and scheduling within machine social networks in the context of Metcalfe's Law. The coming tsunami of machine-to-machine interconnections could yield tremendous flows of information – and knowledge. Once we free the machine social network (comprised of sensors and an unimaginable number of other devices) from the drag of human interaction, there is tremendous potential for creating autonomous communities of machines that require only occasional interaction with, or reporting to, humans.

The conventional wisdom is that the expansive address space of IPv6 solves the IoT problem of myriad end devices. But the host-to-host assumptions fossilized into the IP protocol in the 1970s fundamentally limited its utility for the very edge of the IoT network. As the Internet of Things expands exponentially over the coming years, it will be expected to connect to devices that are cheaper, dumber, and more diverse.

Traditional networking thinking will fail for multiple reasons.

First, although IPv6 provides an address for these devices, the largest population of these appliances, sensors, and actuators will lack the horsepower in terms of processors, memory, and bandwidth to run the bloated IP protocol stack. It simply does not make financial sense to burden a simple sensor with all of the protocol overhead needed for host-to-host communications.

Second, the conventional implementation of IP protocols implies networking knowledge on the part of device manufacturers: without centrally authorized MAC IDs and end-to-end management, IP falls flat. Many of the hundreds of thousands of manufacturers of all sizes worldwide building moisture sensors, streetlights, and toasters lack the technical expertise to implement legacy network technology in traditional ways.

Third, the data needs of the IoT are completely different from the global Internet. Most communications will be terse machine-to-machine interchanges that are largely asymmetrical, with much more data flowing in one direction (sensor to server, for example) than in the other. And in most cases, losing an individual message to an intermittent or noisy connection will be no big deal.

Unlike the traditional Internet, which is primarily human-oriented (and thus averse to data loss), much of the Internet of Things traffic will be analyzed over time, not acted upon immediately. Most of the end devices will be essentially autonomous, operating independently whether anyone is "listening" or not.

Fourth, when there are real-time sensing and response loops needed in the Internet of Things, traditional network architectures with their round-trip control loops will be problematic. Instead, a way would be needed to engender independent local control loops managing the "business" of appliances, sensors, and actuators while still permitting occasional "advise and consent" communications with central servers.

Finally, and most importantly, traditional IP peer-to-peer relationships lock out much of the potential richness of the Internet of Things. There will be vast streams of data flowing, many of which are unknown or unplanned. Only a publish/subscribe architecture allows us to tap into this knowledge by discovering interesting data flows and relationships. And only a publish/subscribe network can scale to the tremendous size of the coming Internet of Things.

The only systems on earth that have ever scaled to the size and scope of the Internet things are natural systems: pollen distribution, ant colonies, redwoods, and so on.

From examining these natural systems, I developed the concept of a three-tiered IoT architecture described in this book: simple end devices; networking specialist propagator nodes, and information-seeking integrator functions. In these pages, I'll explain why terse, self-classified messages, networking overhead isolated to a specialized tier of devices, and the publish/subscribe relationships formed are the only way to fully distill the power of the coming Internet of Things.

Francis daCosta
Santa Clara, California, 2013

With the rise of machines talking with machines in the Internet of Things, a new category of applications will demand evolutionary changes in the infrastructure of networks. Traditional networks were built to keep the enterprise at the center, resulting in star topologies and round-trip communications from edge devices to the servers at the center of the network. The Internet was similarly designed around information at the center of the network connected to people at the edges.

But machines are different from people, with different communications needs. Machines operate more independently in real-time and their actions affect the physical world immediately. Feedback and control of these local actions is critical for top performance and safety. Unlike the traditional end-to-end Internet, the Internet of Things must address these deterministic local control loops to insure business process reliability.

The different needs of machine communications can be seen in three aspects: real-time response, deterministic performance, and security and safety. All three aspects make demands on networking – closed control loops near the machines (to reduce latency), reduced costs of data transmission (in light of the rapidly expanding population of machines), and segregation of communications (to reduce noise and increase security).

With the increased number of devices and variety of applications, Metcalfe's Law is exploding with the number of new machines and the amount of data they generate. The only way for technology to keep up with the coming expansion of the Internet of Things is to manage the machine data flows differently from the way human application-oriented traffic has been handled with current protocols.

This book describes a critical new approach for the Internet of Things that makes it possible to extract meaning in context from the billions of new data sources that will emerge. This new approach recognizes the different demands of machine-to-machine networks and proposes an evolutionary three-tiered architecture to enable the next phase of the Internet.

Francis daCosta is distinctively qualified to develop this new IoT architecture. His diverse background in autonomous robotics, embedded systems, big data analysis, and wireless networking places him at the center of the all of the different technologies which must combine to address the Internet of Things. When Francis talks about communications realms, segregation of data streams, determinism, security, and control loops, I know that he is taking an innovative and disruptive approach in the evolutionary world of networks. This new architecture provides the urgently needed tools to address the expanding needs of the machines that join the physical world to the digital world in the Internet of Things.

Alok Batra
CEO, MQIdentity, Inc.
Former CTO & Chief Architect, GE Global Software Center, Industrial Internet Platform

Rethinking the Internet of Things

For many pundits (and product managers), the Internet of Things is simply another place to apply the same old traditional networking ideas, such as IPv6. But in actuality, a completely different approach is needed if the IoT is truly to reach its potential. That approach will be informed by lessons learned from nature and other massive interacting systems. Follow along and let me know what you think.

Wednesday, September 5, 2012

Think Like an Ant

The title of this blog post is slightly misleading, because I'm finding that to "think like an ant" would mean almost not at all. Many species of insects, such as ants, bees, and termites, form social colonies often characterized by one reproductive individual (the queen) and hundreds to millions of non-reproductive workers (in bees and ants, all these workers are female). Because these colonies in some ways essentially form a single distributed individual, they are often referred to as "SuperOrganisms".

These are complex societies, complete with clear divisions of labor, the ability to exploit new food sources and defend the nest from enemies, and the capacity to move the entire community to a new nest location if necessary. But there is no centralized "command and control" by the queen or any other individual.

In place of any centralized control are a set of highly-evolved behaviors that each individual is essentially born with. Ant workers begin these tasks from the moment they emerge as recognizable adults, often immediately beginning to care for nearby young in the brood chamber. No on-the-job training, no instruction from mission control, no learning. They simply operate.

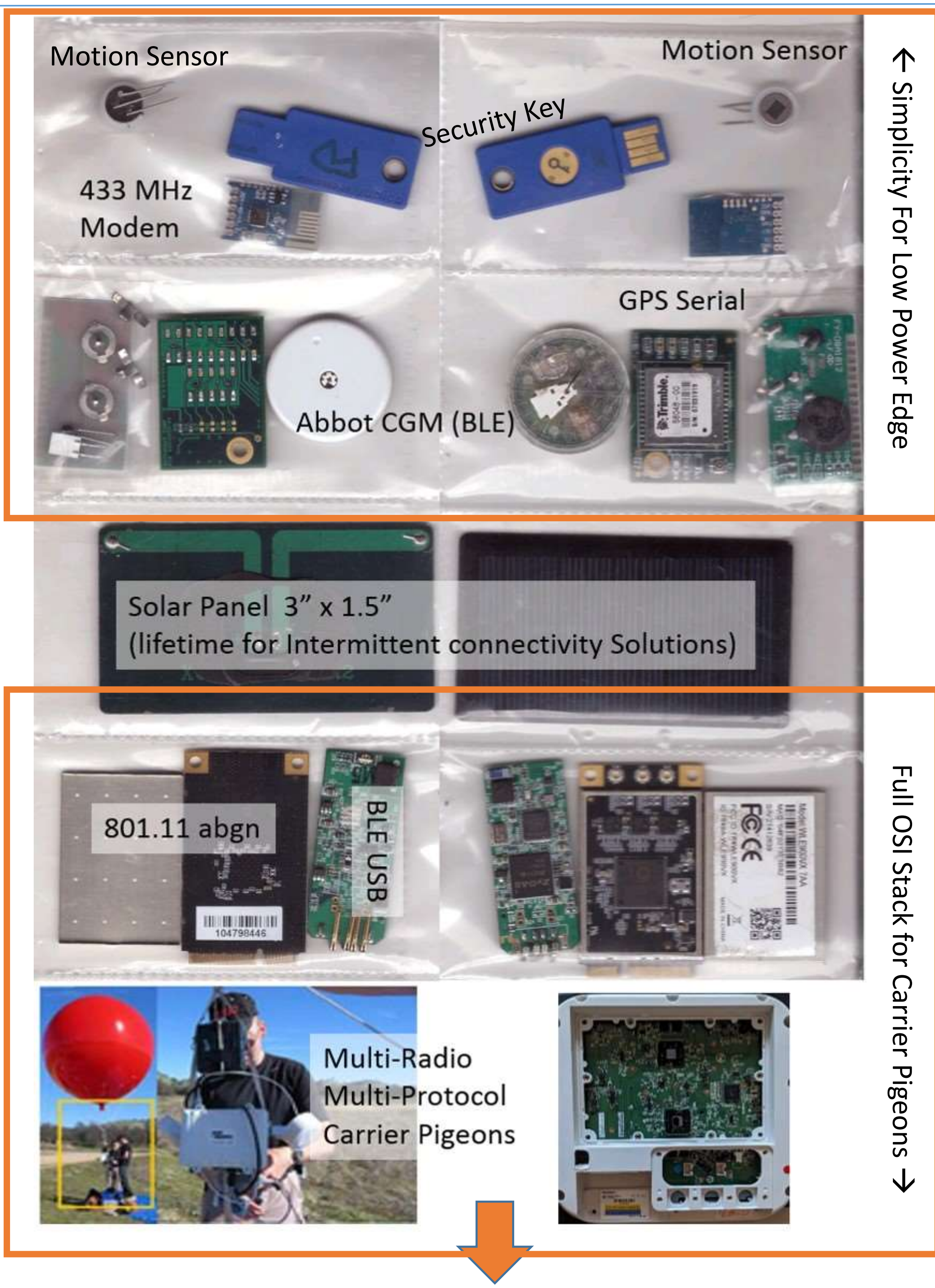
Often worker activities are guided by a simple algorithm selecting from a small set of choices based on situation. For example, an ant worker encountering a hungry larva in the brood chamber feeds it. If the same ant encounters the same larva outside the brood chamber, she carries it back to the brood chamber, hungry or not. A relatively small set of these highly-evolved simple decision trees is multiplied by thousands (or even millions) of workers and then integrated in the form of the colony to result in a highly adaptive, seemingly very intelligent SuperOrganism. But the actual decision-making process of any *individual* worker is very simple.

These basic principles of individual simplicity and collective sophistication could be mirrored in the structure of the Internet of Things. End devices may be outfitted with only the barest of intelligence, simply broadcasting their state or responding to simple direction from other functions.

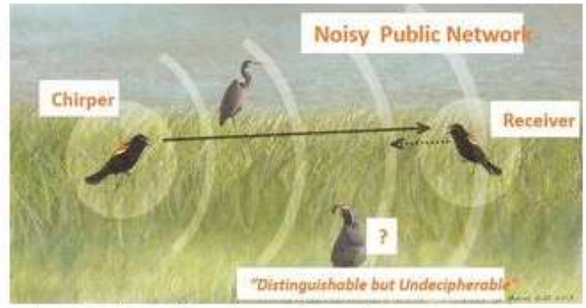
Contributors

- Byron Henderson
- Francis daCosta

Imprinted Chirpers → Imprinted Pigeons → Message Brokers → Subscribers



***Small Dumb Cheap Copious* + Secure = Massive IoT**



Small Dumb Cheap Copious – and Secure

Fig. 1. Left. Key Challenges to "Massive IoT" : Energy, Complexity, Density + Security.
Fig. 2. Right. Nature's Massive IoT uses light, power constrained, cryptic receiver biased messaging.

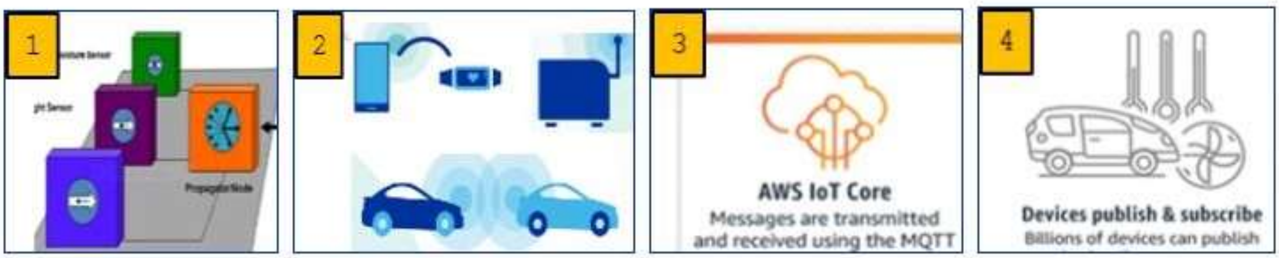
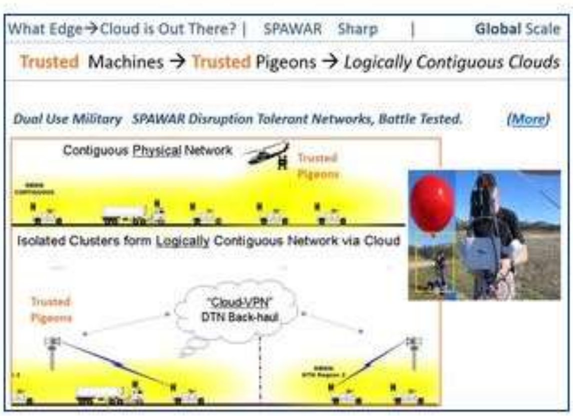


Fig. 3. Soft Chip™ - Imprinted Sensor Patches -> Data Logs -> Pigeons -> Cloud -> Intelligence



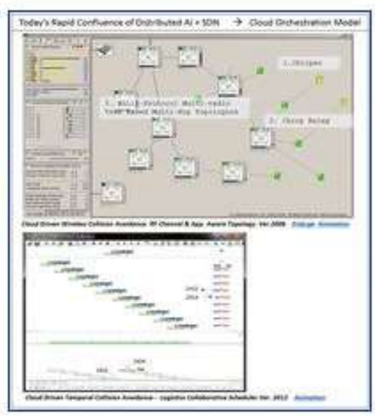


Fig. 4. Left. Logically Contiguous Cloud - where the Cloud joins "broken" connections.
Fig. 5. Center Cloud Orchestration Model - where RF channels, schedules driven by cloud intelligence.
Fig. 6. Right. Soft Chip™ Work Flow - How Edge Intelligence is harvested by Cloud Subscribers. Enlarge

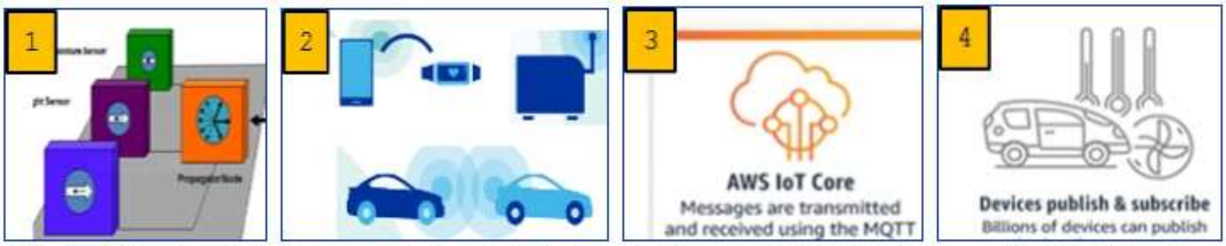
---

This glossary describes how digital versions of Ants, Chirps, Edge, Pollen are used to describe a shift in thinking from Edge->Cloud to Cloud Driven Edge, for **ultra-low power devices operating in remote regions.**

Abstracted Internet. A radio hardware and radio protocol abstracted world where cloud servers manage last mile network topology, RF channel diversity and the timing of when Edge devices speak, listen and relay. This timing is based on application awareness - when and with what frequency Edge sensory data is needed.

Ant-like. See also Deterministic Finite Automata Specific Purpose Reprogrammable behaviors.

Carrier Pigeons, Pigeons, Propagators. The packet transport from rudimentary edge protocol to cloud. RFID readers encapsulates the raw signals into a useful format. Pigeons, over a rudimentary - and legacy supported - serial modem. take in Chirp packets. tag and prune them and put them on a shuttle bus to



Soft Chip™ - Imprinted Sensor Patches -> Data Logs -> Pigeons -> Cloud -> Actionable Intelligence

■ Rationale for Soft Chips™

Chirp protocols are generic and intentionally rudimentary- they can run on any radio and coexist with any existing protocol. When Chirps are detected, Chirp protocol handlers run - in the phones or on USB modems. Simple ant-like edge intelligence is imprinted to provide When-this-then-that and If-when-this-then-that processes. Soft Chips - as the same suggests, can have their behaviors modified. Suites of sensors can be activated by imprinted code to perform specific tasks using specific sensors e.g. make data logs, relay "fire!" alerts, corroborate multi-sensor feeds. Soft Chips may be made in millions because they support multiple use cases and are future proof- because of the radio and protocol agnostic nature of Chirps.

Intended benefits of these embodiments are in them being:

- . Small — Small Radio Power Usage and Footprint - Long Battery life.
- . Dumb — Limited Ant-like processing capabilities - but re-programmable.
- . Cheap — Intended to be produced in millions - since multi-use.
- . Copious — Intended to be used like seeding crops - deep ground truth verification.
- . Secure — Imprinting process - end-to-end - is innately secure. USB modems add security.
- . Custom — No central standards committee needed. Modem based Chirp protocol custom.
- . Agnostic — Chirps are radio and protocol agnostic. Can coexist with other protocols.

■ Soft Chips™ and CHIPS initiatives.

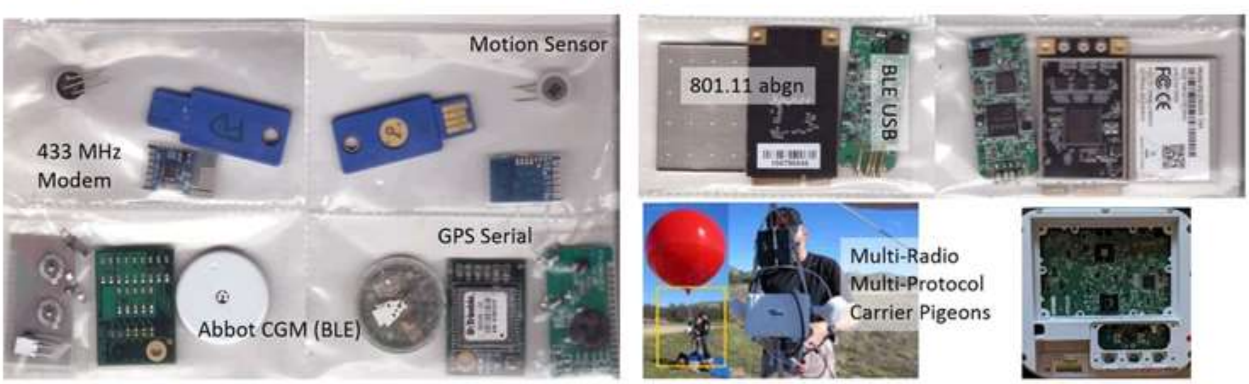
Soft Chips embodiments are intended for dual use (military and industrial) since the security is in the imprinting services provided by trusted hosted services. The two ends of wireless modem have to "match" or know of each others' schedules and RF channel usage and handshake protocols. End-to-End and zero trust.

In our polarized world, governments and military deploy edge devices imprinted by them to provide womb-to-tomb ground truth verification. Sensitive data is not sent over foreign networks and equipment. Covert networks over trusted devices are used. Business is war watered down. Today, all Global enterprises and Regulatory agencies run on federated "Clouds" and expect authentic data from their assets on the ground.

CHIPS initiatives - "integral to America's economic and national security" benefit from collaborative sharing of trusted, previously walled private gardens. Globally Relevant challenges are now addressable.

Global scale challenges mandate Globally Relevant Edge à Cloud solutions.

■ Soft Chips™ and Dual Use Cases (military and industrial).



Simplicity For Power Constrained Edge — Full OSI stack for Powered Carrier Pigeons

Fig. 2: Serial Modems are small dumb cheap copious. Carrier pigeons using BLE, WiFi, mesh are powered

Imprinting. Soft Chip products are imprinted - establishing provenance to "Mother". On power up chirp devices first scan/listen for "Mother" on private channels and cryptic protocols. Receiver radios on phones or drones respond and imprint the devices. If RF interference occurs, the cloud directs them to other channels or schedules - teaches them new tricks. Imprints provide an end-to-end trusted system.

Establishing provenance of sourced materials - which tree in which forest - has to come from imprinted tags that follow the tree from the forest to the lumber yard and onwards to Home Depot. Provenance chains kick in

Mesh Architectures

Introduction

Mesh network requirements have evolved from their military origins as requirements have moved from the battlefield to the service provider and residential networking environments. Today, to cover large areas with a single wired Internet link, more cost effective and efficient means of bandwidth distribution are needed. This implies more relay nodes (hops) than were needed before. Further, a growing VoIP market expects VoIP packet to occur over the mesh with both low latency and low jitter. These new mesh requirements (more hops to cover large areas, more efficient bandwidth distribution and better latency and jitter for VoIP) has given rise to the 3rd generation of mesh architectures.

Three Generations of Mesh Architectures

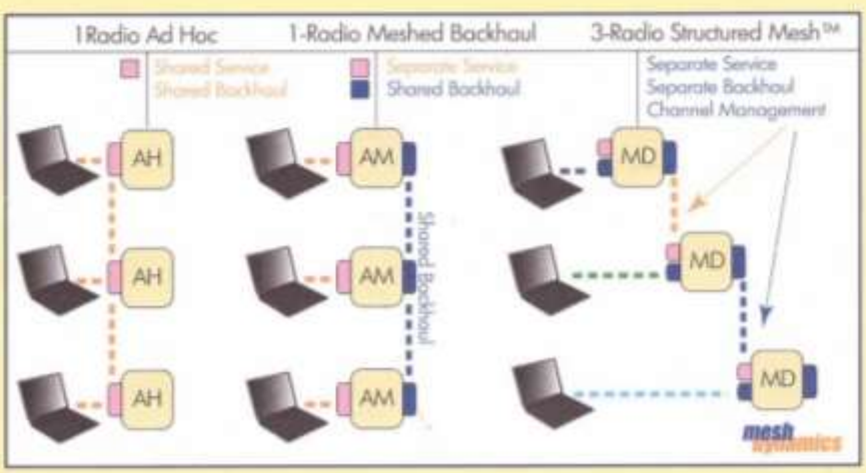


Fig 1: (L-R): Ad Hoc, 1-Radio Meshed Backhaul, 3-radio Structured Mesh

Three generations of evolving mesh architectures are depicted above. They are (Left to Right):

First Generation: 1-Radio Ad Hoc Mesh (left). This network uses one radio channel both to service clients and to provide the mesh backhaul. The ad hoc mesh radio, marked AH, provides both services – client access and backhaul. This architecture provides the worst services of all the options, as expected, since both backhaul and service compete for bandwidth.

Second Generation: Dual-Radio with Single Radio Ad-Hoc meshed backhaul (center). This configuration can also be referred to as a "1+1" network since each node contains two radios.

4. Autonomous Industrial IOT Network Implementation (SPAWAR)

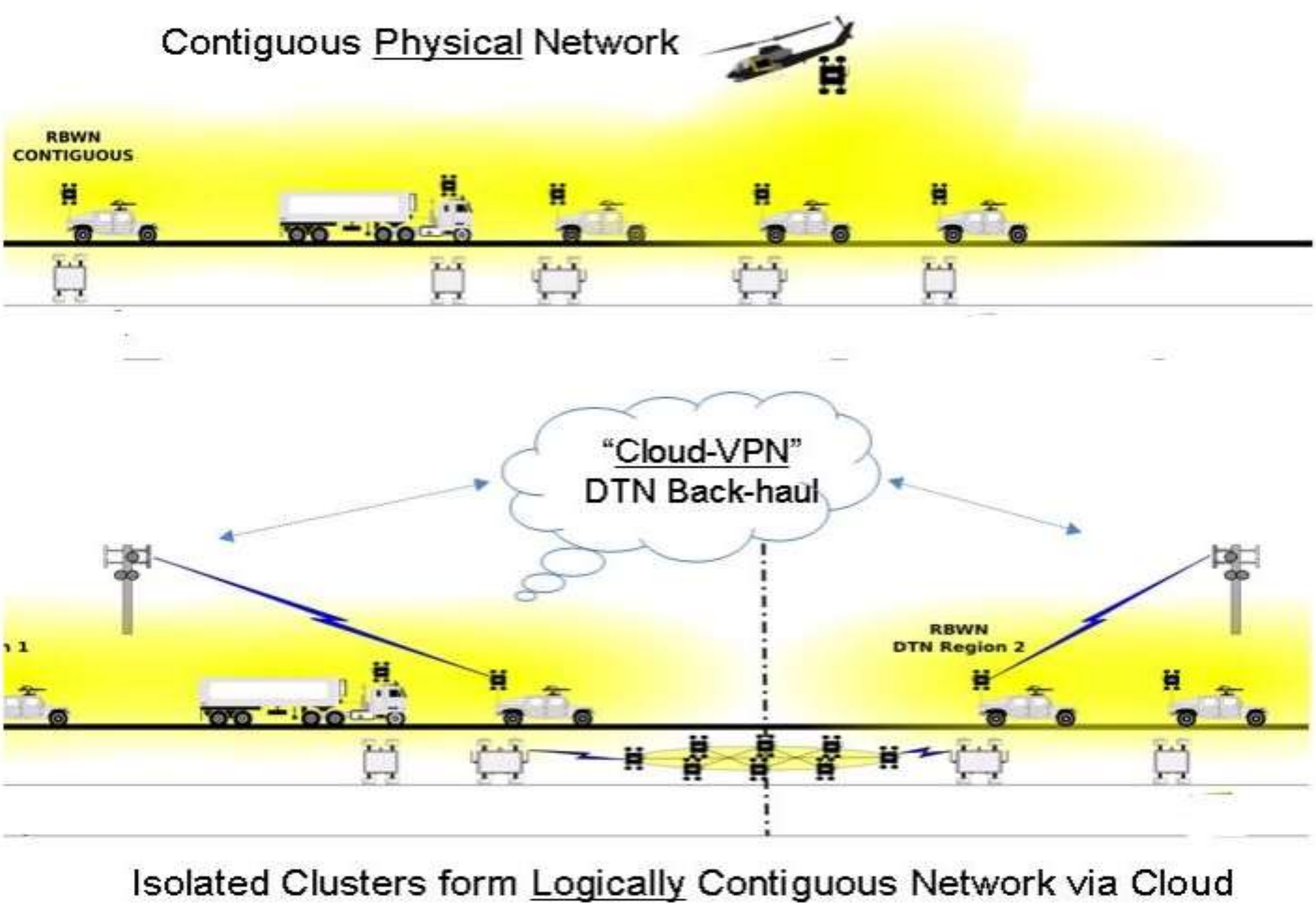


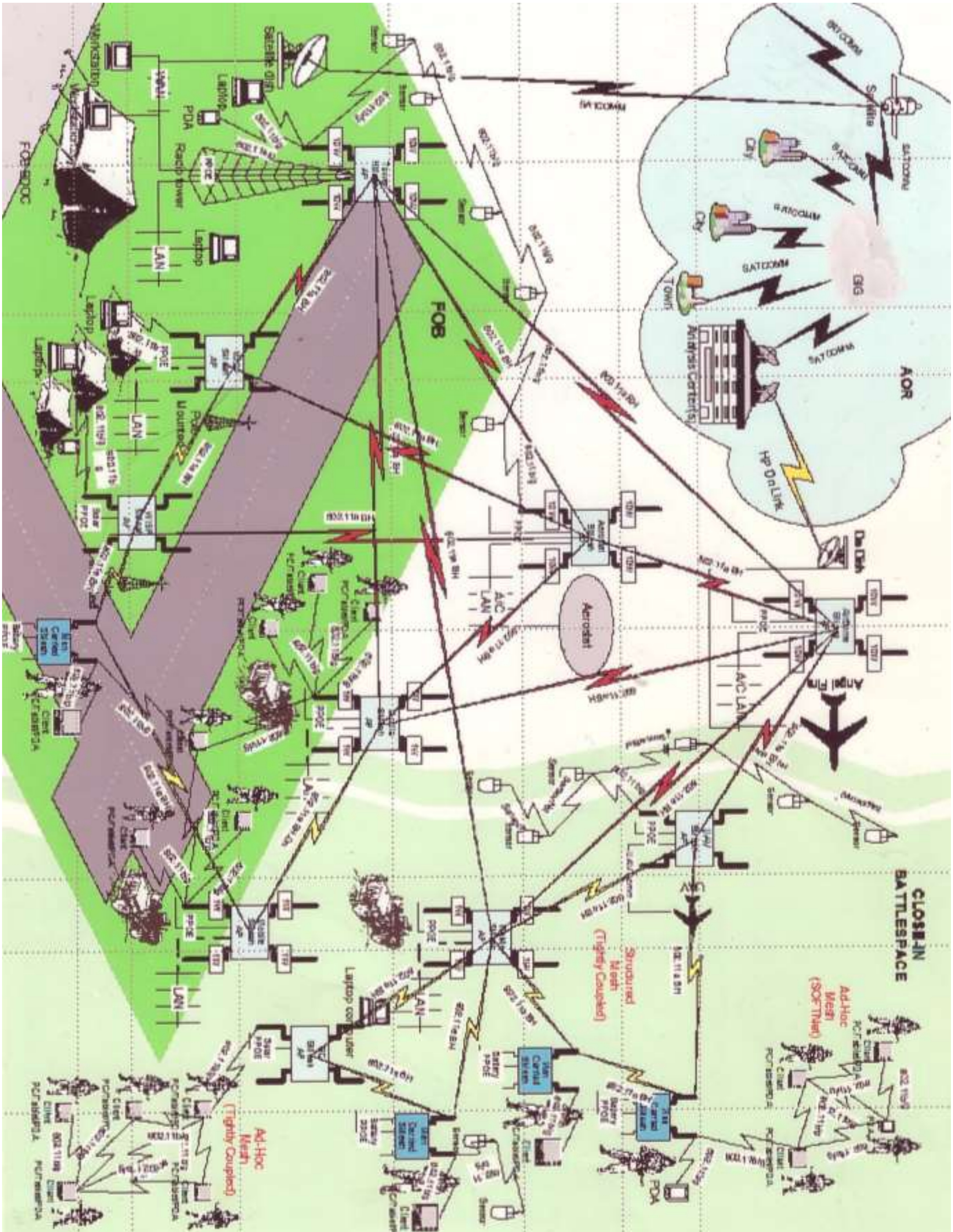
Fig 4: Disruption Tolerant, Semi-autonomous networks (SPAWAR)

Meshdynamics has been developing an open-source propagator platform for disruption tolerant networking for the US Navy and US Department of Energy. Propagator nodes support User Space Application Layer within an OpenWRT architecture for deep packet inspection, SDN based routing, Video, IFTTT (conditional "If This Then That" rules), etc. These propagator nodes provide autonomous, robust machine control with no assurance of internet connectivity through the built-in applications agents.

Nearly everything described above takes place autonomously and automatically within the Disruption Tolerant Mesh Network. Propagators and their applications even route around failures of links or nodes and deal with issues created by mobility of network elements. But some of the most important capabilities of propagators are distributed application intelligence agents that can allow higher level functions to "tune" the propagator network as part of an overall publication/discover/subscribe infrastructure and/or create application instantiations (e.g. machine controllers) within the nodes themselves. These permit connected devices to continue to operate when the broader network connection is lost. [More]

The end result is a Publish/Subscribe (Pub Sub) network that can be extended from Big Data servers all the way to the edge of the network while still maintaining a degree of responsive local autonomy. A variety of standards- based SDN protocols may be implemented on the distributed applications agents.

"Meshdynamics Scalable and Open Pub Sub enables us to rapidly integrate with Enterprise Class, OMG (Object Management Group)-approved, industry- standard messaging systems from RTI (Real-Time Innovations), PRISMTECH, OpenDDS, and others to provide assured real time end to end performance, even if we scale to billions of devices at the edge." Curtis Wright, Sr. Research Systems Engineer, Space and Navy Warfare Center.


FOB
AOR
GIG
CLOSE-IN BATTLESPACE
Aerostat
Ad-Hoc Mesh (Tightly Coupled)
Structured Mesh (Tightly Coupled)
Ad-Hoc Mesh (SOFTNet)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◆理論最大値 1.3Gbps のデータリンク速度
(IEEE802.11ac 3X3MIMO)
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安定性
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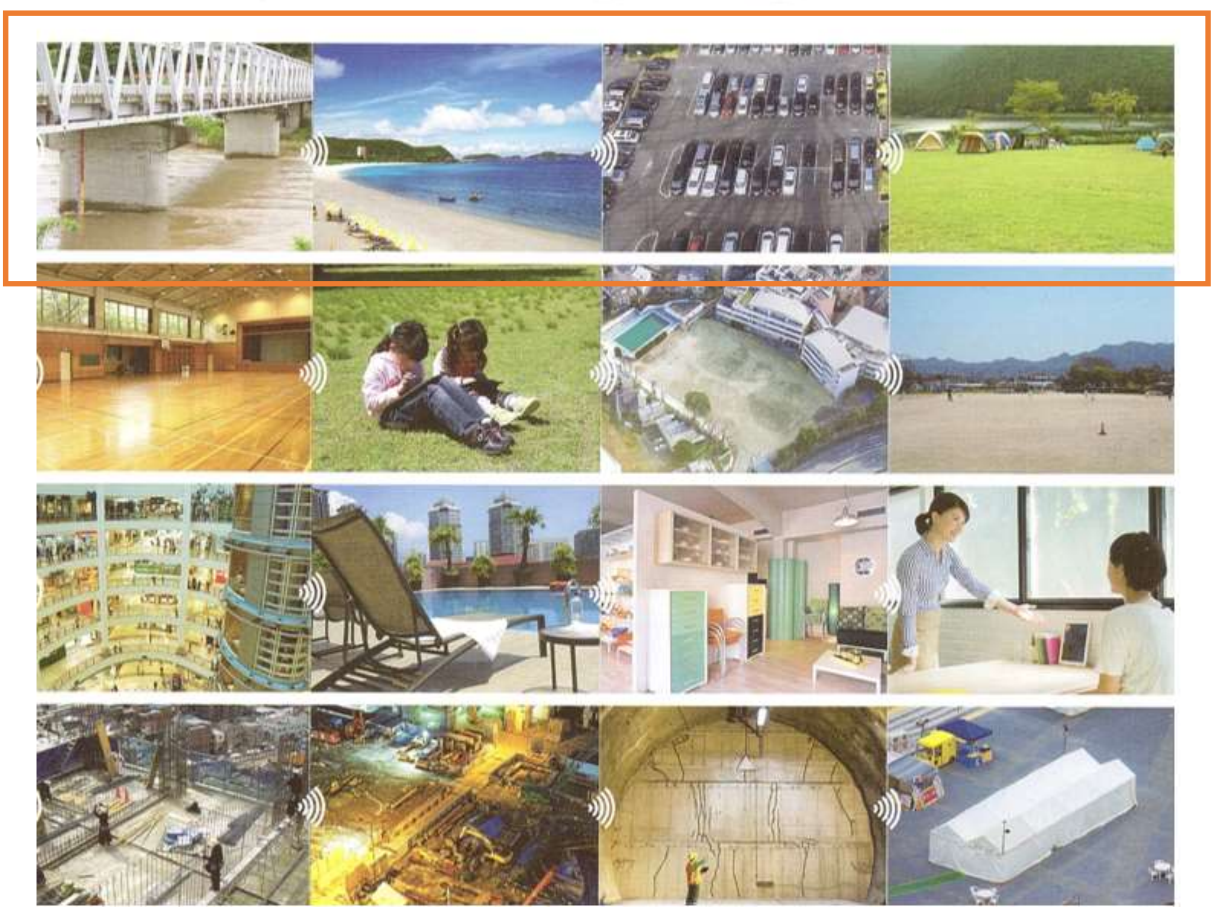
耐候設計
システム
拡張性
◆Sub-GHz 無線ユニット



SHARP

Wireless Smart Network

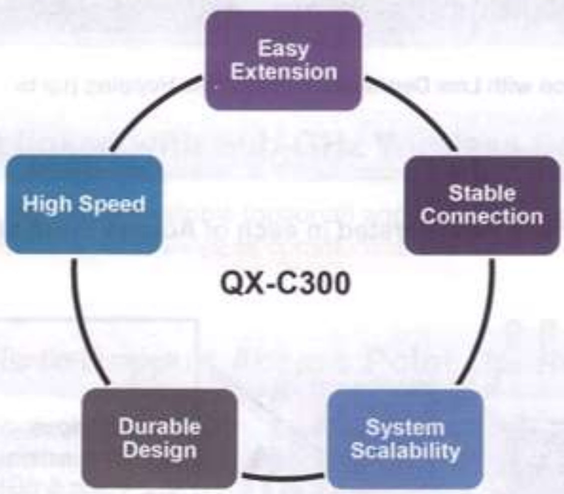
Press Release

Wireless Backhaul Access Point QX-C300 Series

for Japan domestic market

Suggested retail price: 335,000 JP Yen + tax

New information service will be implemented in smart network society by high-speed wireless LAN environment



■ High-speed, Stable & Smooth Network Connection made possible by Wireless Backhaul Access Point

- IEEE802.11ac (3x3 MIMO), High-speed Data Transfer
- 1.3Gbps Link Speed (max): Approx 3X (max) speed of IEEE802.11n Access Point (*)
- 4.9GHz Model Available (Less Radio Wave Interference): Total of 4 models available to support customers use cases.
- Concurrent Connection: Up to 126 units per 1 Access Point
- Flexible Relocation and Extension of Access Points

(*) : theoretical value

1

http://www.sharp.co.jp/business/smartnetwork/products/qxc300.html

https://meshdynamics.com/ACG/company.htm

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MILESTONES 1992- 2005

Advanced Cybernetics Group was founded in 1992, to develop distributed and adaptive control systems for mission critical military applications. These systems exhibit modular, scalable, extensible and self healing characteristics, essential for the harsh and hostile environments they are deployed in.

1992-1998, ACG was awarded multiple phase contracts by the US Air Force (USAF) and the National Institute of Standards and Technology (NIST) to develop software for mission critical systems operating in dynamic, hostile, environments. [ACG YouTube Video]

During this time ACG also productized the framework for these adaptive, self healing and self learning distributed control systems. We developed and licensed factory automation solutions to Abbott, IBM, Babcock and Wilcox, Ingersoll-Rand, Komag, Motorola, Seagate etc. [Permitted Disclosures]

1998-2001. Scalable, distributed control methodologies were applied to automate parallel context driven web search. Knowmadic was founded in 1998, to commercialize software for automated extraction of "salient" snippets from multiple web sites. Artificial Intelligence techniques were deployed to lock on to formatting, structure and content cues and accurately locate target snippets. Enterprise clients included Citibank, Chase, Enron, Fidelity, Hambrecht & Quist, TXU, etc. [Knowmadic YouTube]

2002-2005. A distributed control approach was applied to wireless last mile connectivity, specifically at the edge of industrial and military mobile networks. A scalable, distributed architecture was devised that supported both single and multi-radio mesh networking in one interoperable, collaborative framework. At its core, it is a wireless analogy to (wired) Layer 2 switch stacks. These wireless versions of switch stacks exhibit unprecedented scalability and self healing capabilities. [MeshDynamics YouTube].

Advanced Cybernetics Group is a private minority owned small disadvantaged business (SDB). We are an approved US Department of Defense contractor. References are available.

For more information, please contact Francis daCosta, Founder and CTO. Contact Us

EETIMES NETWORK

"ACG's technology could close the rift between hardware & software engineers by enabling them to use the same high level language to describe their designs."

An Integrated Prototyping Environment For Programmable Automation
(Published SPIE/OE 92 International Symposium on Intelligent Robots In Space)

F. daCosta ACG, Inc. San Jose, CA

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Abstract

We are implementing a rapid prototyping environment for robotic systems, based on tenets of modularity, reconfigurability and extendibility that may help build robot systems "faster, better and cheaper". Given a task specification, (e.g. repair brake assembly), the user browses through a library of building blocks that include both hardware and software components. Software advisors or critics recommend how blocks may be "snapped" together to speedily construct alternative ways to satisfy task requirements. Mechanisms to allow "swapping" competing modules for comparative test and evaluation studies are also included in the prototyping environment. After some iterations, a stable configuration or "wiring diagram" emerges. This customized version of the general prototyping environment still contains all the hooks needed to incorporate future improvements in component technologies and to obviate unplanned obsolescence. The prototyping environment so described is relevant for both interactive robot programming (telerobotics) and iterative robot system development (prototyping).

Introduction

Escalating costs and long lead times associated with building robotics and automation systems favor automation of the process of designing automation systems itself. Lack of a higher level of automation in the product life cycle support of automation systems has resulted in increased cost of the end product, lower quality, and increased lead time. This is especially true for automated manufacture, re manufacture and repair of small quantity or one-of-a-kind items; lack of economies of scale prohibit the development of custom systems for them. Unfortunately, the bulk of components comprising today's weapon systems (and much of civil systems) fall in this category. Despite diverse application domains[1, 2, 3, 4, 5], there is a marked similarity in their needs to program robots "faster, better and cheaper". With shrinking operating budgets, there is strong incentive to automate the process of maintenance and repair, currently performed manually. The high cost of programming robots must be addressed by developing techniques to automatically program them. The Dod Critical Technologies Plan has specified the near term technology objective: "Planning and control of robotic assembly from CAD models" by 1996[6]. Similar interests, related to variable autonomy, have been expressed by NASA[4].

We are implementing a rapid prototyping environment for the design of robotic systems that includes a library of commercially available "lego blocks" consisting of hardware modules (such as robots, tools and sensors), complementary software modules (such as sensing strategies, and robot motion control) and a family of software advisors or critics designed to reduce the costs of programming robots. These include (CAD model driven) assemblability sequencing, robot motion planners and grasp strategy selection.

In addition to reducing programming costs, the prototyping environment will allow users to quickly generate and evaluate alternate approaches to design of an automation system. Thus, program managers can view how the robot will put together the parts in alternative assembly sequences and, consequently, be able to make a more informed decision. This work is relevant to small batch factory floor automation. It is also relevant to field robotics, where critics, as part of a telerobotic interface, could support cooperative robot-human interaction in harsh or remote areas.

Related Work

The main advantage for robots is their ability to be (re)programmed. There are three levels at which to do this: Joint level, Manipulator level and Task level. Joint level programs describe motion commands required by robot joint motors. It is the lowest and most flexible level at which robots can be programmed. Writing programs at this level is a painfully tedious process requiring specialized knowledge. Further, the software developed is both device and application specific. Manipulator level programs build upon joint level programs to enable users to describe actions required of the robot to perform a task as opposed to individual joint motions. A robot program is written as a sequence of robot manipulator language primitives such as move and open-gripper commands. Several manipulator level languages exist; they suffer from the following limitations: 1) the programming languages are primitive, many do not support standard programming constructs such as recursion or abstract data types; 2) there exist a plethora of robot programming languages with no common features across languages, making robot programs non-transportable and 3) robot programmers are required to have an intimate knowledge of robots, sensors and programming languages.

Off Line Programming Environments[21, 22] are a variant of manipulator level programming. They are graphic simulation platforms that provide a subset of primitives commonly used by various robot vendors. The robot programmer has to learn only the simulation language and not any of the robot programming languages. However, the current state of art in off-line systems suffers from two serious drawbacks; first, it is at best a robot motion simulator and second, does not

Towards Rapid Implementation of Adaptive Robotic Systems

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Introduction

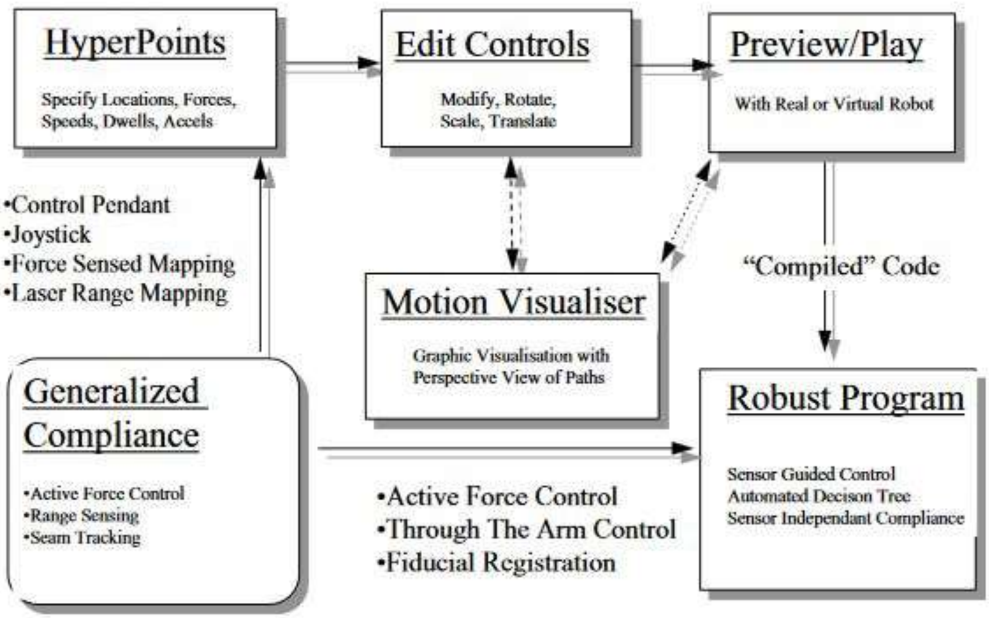

Figure 1: Lego block approach Adaptive Real time Embedded System Design

Current automation design practice produces expensive one-of-a-kind installations where the system cannot be easily modified to meet changing demands or advancements in technology. It is imperative that we design robot systems to be modular, portable and easily re-configurable in order to reduce the design lead times and life cycle costs of providing automation alternatives.

The Unified Tele-robotics Architecture Program (UTAP) was developed under the sponsorship of the US Air Force Robotics and Automation Center of Excellence. A goal of the program was to define and develop prototypes of commonly used software building blocks for sensor guided real time embedded control of telerobotic devices. Standard building blocks and a non-proprietary communication protocols would provide the Air Force and specifically the Logistic Centers with a support infrastructure designed to rapidly and efficiently build and maintain mission critical automation systems.

This paper restricts itself to unclassified applications of the technology. Three (unclassified) applications of interest to the Air Force were explored: Paint Stripping, Surface Finishing/Grinding and vision based inspection. The three applications were chosen because of striking commonalities:

- Some form of dynamic contour following needed, with motion parameters altered in real time
- A multi sensor situation is typical: Multiple inputs collectively define the new set point.
- The software modules are identical in function, if the data passed can be parameterized correctly.

Based on these observations, ACG implemented a "flexible" programming environment for sensor guided contour following tasks. All software, including the visualization sub system, was implemented in our real time OS. The software is being used at Schlage Lock to rapidly generate all the programs for robotic door handle polishing cells. A subset of the software system is in operation at Warner Robins AFB, where it is being used to strip paint off F-18 aircraft.

We briefly describe three modules that are applicable to non-military applications: the Hyper Point Data structure, The Generalized Compliance Module and the Robot Motion Visualization Module.

The Hyper Point data structure and usage

Contour following is the process of moving along a path while changing motion parameters regulates the motion along the path.

adept news

FOR IMMEDIATE RELEASE

Contact:
Roger J. Boss
408/434-5021

ACG TO DEVELOP THIRD PARTY SOFTWARE FOR ADEPT

DETROIT, MI Cobo Hall, Robots & Vision Show, Booth #301 (May 9, 1995) — Adept Technology, Inc., a world leader in the factory automation industry, today announced with Advanced Cybernetics Group (ACG) a software development agreement that will greatly increase software applications and utilities for the Adept MV Controller.

Under the terms of the agreement, Adept will utilize the resources and support services of ACG to create developmental software for Adept's V+ language and operating system. The move signifies Adept's continued drive toward an open industrial controls solution.

The development of third party software for the Adept MV Controller allows manufacturers to fully capitalize on the strengthens of the Adept V+ language and operating system. Adept Senior Vice President of Sales and Marketing, Charlie Duncheon comments, "With over 10,000 installations, the V+ language and operating system is the choice of industrial manufacturers world wide. Adept actively supports and encourages the development of third party software products for Adept controllers. The developmental efforts of such partners as ACG benefit all V+ users by delivering increased functionality and tool sets for our robust MV Controllers."

ACG, an Adept MV Partner, develops advanced software tools to program robots quickly and cost effectively. ACG products include the HyperPoint Polishing Module, V+ File Manager, and V+ GUI Interface Builder. ACG product information can be obtained directly from Advanced Cybernetics Group, Sunnyvale, CA: (408) 747-1413.

Adept Technology, Inc. is America's largest manufacturer of industrial robots and a factory automation leader with more than 7000 systems installed worldwide. Annual revenues for the San Jose, California company exceed $55 million. Adept provides direct sales, service, and training in the U.S., Europe, and Japan and offers turn-key flexible automation systems through specialized automation engineering companies throughout the world. Adept maintains offices in Cincinnati, Ohio; Southbury, Connecticut; Detroit, Michigan; Dortmund, Germany; Arezzo, Italy; Palaiseau, France; Kennilworth, England; and Toyohashi, Japan. Additional information can be obtained from the Company's World Wide Web page: http://www.industry.net/adept

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Adept Technology, Inc • 150 Rose Orchard Way • San Jose, CA 95134 • 408/432-0888

Oct 1 16:15 1991 LeahyAppreciation Page 1

From mleahy@blackbird.afit.af.mil Wed Jul 3 17:13:02 1991
Received: from mwunix.mitre.org by starbase.mitre.org (4.1/SMI-4.1)
id AA16418; Wed, 3 Jul 91 17:13:01 EDT
Return-Path: <mleahy@blackbird.afit.af.mil>
Received: from [129.92.1.2] by mwunix.mitre.org (5.61/SMI-2.2)
id AA00679; Wed, 3 Jul 91 17:13:59 -0400
Received: by blackbird.afit.af.mil (5.64+/a0.25)
id AA00439; Wed, 3 Jul 91 16:54:48 -0400
Date: Wed, 3 Jul 91 16:54:48 -0400
From: Michael B. Leahy Jr. <mleahy@blackbird.afit.af.mil>
Message-Id: <9107032054.AA00439@blackbird.afit.af.mil>
To: daco@starbase.mitre.org
Subject: appreciation letter
Status: OR

Dear sir,

I am writing to express my appreciation for the assistance that Francis Dacosta has been able to provide on several issues relating to robotics and automation technology. I am an associate professor of electrical engineering and Director of the Robotic Systems Laboratory at the Air Force Institute of Technology. One of my job responsibilities is to provide consulting services to various Air Force organizations. The main recipient of those services is the newly created AFLC Robotics and Automation Center of Excellence (RACE) at SA-ALC.

Francis had the opportunity to meet my RACE contacts at an AI symposium at SA-ALC. Impressed with his grasp of remanufacturing automation and robotics issues they provided me with his email address. The relationship that has developed since that time has been very rewarding professionally and personally. Francis's keen insights and network of industrial contacts has enhanced my ability to provide technical direction to the RACE staff. His willingness to share his expertise with others in the robotics community enhances his professional reputation and has opened my eyes to a range of skills at Mitre that I was unaware of.

In September I will be reassigned to SA-ALC as RACE program manager. While a main objective of RACE is to develop in-house expertise, we also hope to be able to fund outside research on the enabling technologies required for improving the productivity of depot level remanufacturing processes. I anticipate that Francis's group will provide technically sound responses to the requests for proposals that we initiate.

Michael B. Leahy Jr., Capt, USAF
Associate Professor of Electrical Engineering

MITRE

Date: Mon, 27 Jan 92 07:59:35 -0600
From: mleahy@sadis01.sa.aflc.af.mil (CAPT MIKE LEAHY - TIEST)
Subject: MITRE involvement in RACE
To: maybury@mitre.org
Cc: aweiss@mitre.org
X-Mcf: maybury <Maybury, Mark T> re-routed to "maybury@linus.mitre.org"

Dear Mark,

Francis daCosta has informed me that you are interested in what role I envision Mitre playing in the ALC robotics strategic implementation plan.

A year ago, when I was selected to be the RACE program manager, Mike Starsiak gave me the pitch about Mitre's robotics capabilities. I was skeptical. I was aware of Mitre strengths in electronic areas that supported ESD but not in robotics. After reading the technical publications that Mike provided, I realized that Mitre had some interest in robotics but the robot was primarily viewed as a mobile black box used to further basic research in artifical intelligence. While that work was intellectually stimulating, I saw no applications to the primary technology insertion tasks facing Air Force Logistics today.

So, when the people at Kelly first spoke to me of Frank, I doubted if anything would come of it. I could not have been more wrong. Through our numerous technical conversations, I have come to respect his expertise in a broad range of robotics and automation topics, that directly impact my job. He is the rare individual who combines the rigorous analysis of a good researcher with a pragmatic approach to solving real world problems. His past involvement in the design and implementation of robot systems does not hurt either. I believe that RACE will be successful if we can more effectively harness the talents of people like him. Two ways come to mind.

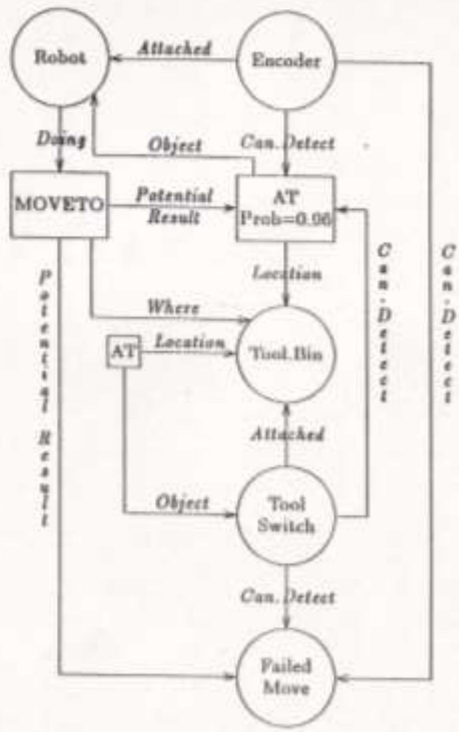
First, Frank's research interests in prototyping closely match RACE mission objectives, which is, to help make ALC operations more cost effective by the judicious insertion of robotics related technologies. The key word in that sentence is judicious. We already have enough monuments to technology thatseemed like great deas but produced minimal impact on productivity. In the current budget environment we cannot afford such mistakes. Commercial offline programming systems enable us to visually present the solution to the process engineer prior to contract award and implementation. But judicious insertion also implies short time lines and reduced expense. And that is where the current technology breaks down. Once we have visualized the design there is no efficient repeatable procedure for transforming that vision into reality. Every new system is a one of with the resultant high cost, lengthy development time, and technical risk. We must develop innovative methods to leverage our prototypes into multiple insertions. As part of the Strategic Implementation Plan RACE has called for development and implementation of the Critics approach to help us prototype robot systems more efficiently and cost effectively.

Second, as both an active member of the robotics research community and as program manager, I encourage attempts to establish a consortium to support ALC and other sponsor needs. Under the aegis of Total Quality Management, RACE is committed to providing the best quality services to the Air Force. But the effort is well beyond the scope of any one research group. Only a coordinated effort encompassing the leading research groups will produce the quality prototyping tools the Air Force needs. I would like the creativity of leading universities to be channeled into this effort. The rapid prototyping consortium idea eliminates a difficulty I have in funding university level research activities. As a federally sponsored lab Mitre could provide an unbiased technical leadership and systems integration support.

As you know, we have requested Industrial Base Process funds to examine the Critics approach more fully. I have sent Frank a draft of the RACE implementation plan and I have asked him to send you a copy. I am encouraging Mitre and others to work with us in jointly developing technologies relevant to RACE. I look forward to a higher level of participation from Mitre in supporting our prototyping needs.

Sincerely,
MICHAEL B. LEAHY, JR., Capt, USAF, PhD
ALC RACE Program Manager

ERROR CLASSIFICATION - SENSOR CONSENSUS



DEVICE LEVEL SOFTWARE ARCHITECTURE

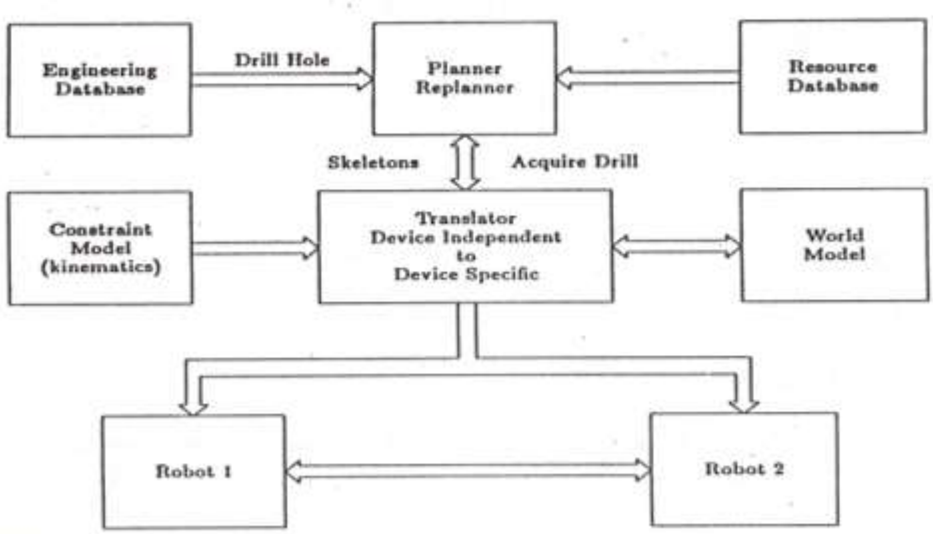


Figure 1: Translation Software Architecture

18 IRD Translation Slide : Show Flow

NORTHROP

Reprinted from: July 13,1984

THE WALL STREET JOURNAL.

TECHNOLOGY

Drive for Higher Productivity Spurs Interest in Exotic Motors

By Doron P. Levin
Staff Reporter of The Wall Street Journal

adept technology, inc.

Francis Dacosta
Application Engineer

1202 Charleston Road
Mountain View, California 94043
415 · 965 · 0557 · Telex 171942

ADEPTABLE ASSEMBLY

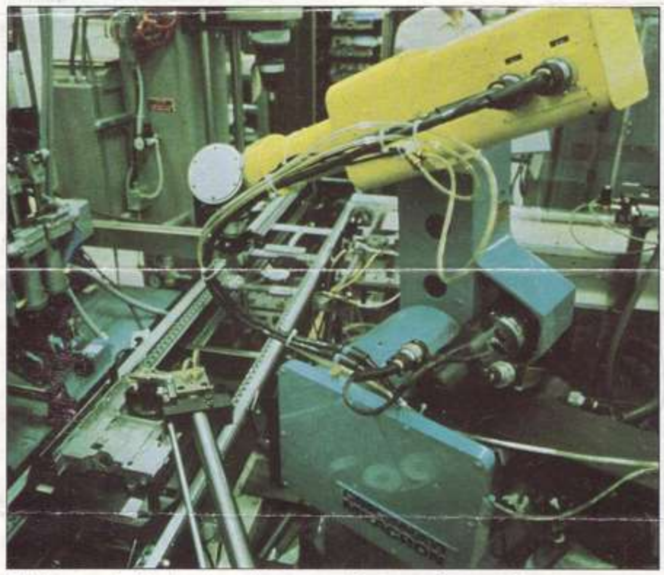
advantage of the direct-drive motor is that it attaches to what it's moving and it operates at the same speed as what it is turning.

Robots Speed Assembly of Floppy Disk Drives

Milacron and Seiko robots complete the job in one-fifth the time required with manual assembly

When it comes to speed in assembly operations, human operators are hard to beat. But manual assembly leaves a lot to be desired where sustained operation, quality, and consistent performance are concerned. In an automated assembly system at Shugart Corp. (Sunnyvale, CA), a robot not only offers these benefits, but also deserves much of the credit for trimming assembly time down to one-fifth of what it was with human operators.

Shugart, a subsidiary of Xerox Corp. and manufacturer of floppy, Winchester, and optical disk drives, installed its first robot assembly cell in the laboratory in February 1982. The system currently used in production was started up in June 1983. It is called a "mechanized spindle assembly station," or MSA for short. It performs the first in a series of assembly operations on the company's SA810/860 half-height, double-sided, 8″ (203 mm) diameter floppy disk drives.

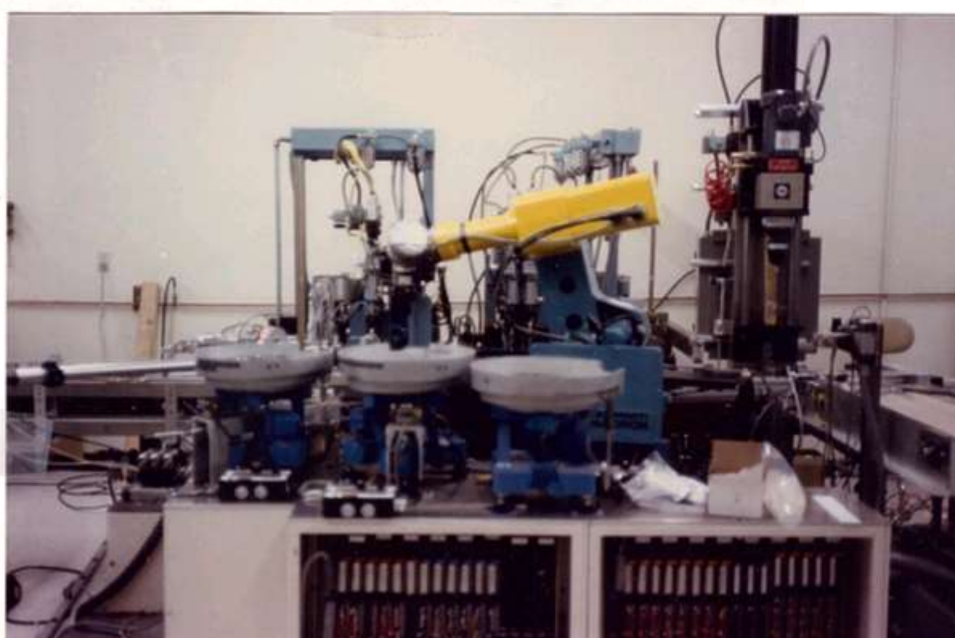


Higher production levels and more consistent product quality are achieved by Shugart with this floppy disk drive assembly workcell.

Francis Dacosta
Senior Advisory Engineer
Industrial Automation

Shugart Associates

Headquarters:
475 Oakmead Parkway
Sunnyvale, California 94086
(408) 733-0100 TWX 910-339-9355



LETTER OF REFERENCE

THIS PORTION TO BE COMPLETED BY CANDIDATE

I Gerson F. daCosta (TYPE) FIRST MIDDLE LAST REQUEST THIS LETTER OF REFERENCE

FROM Ernest G. Chilton (TYPE) FIRST MIDDLE LAST . I PLAN TO USE IT FOR

EMPLOYMENT ☑ ADMISSIONS ☐

I REQUEST A CONFIDENTIAL REFERENCE AND HEREBY WAIVE MY RIGHT TO INSPECT IT.	I REQUEST AN OPEN REFERENCE AND RESERVE THE RIGHT TO INSPECT IT.
Gerson F. daCosta CANDIDATE'S SIGNATURE	CANDIDATE'S SIGNATURE
DATE 22-7-81	DATE

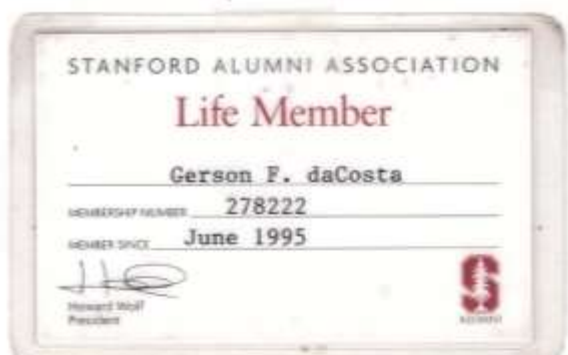
(SIGN ONLY ONE OF THE ABOVE)

(In preparing this statement, please give your critical appraisal of the potential and professional qualifications of the candidate named above; if employer, include specific nature and tenure of employment. Please type this statement.)

I have known Gerson since Autumn 1979. He was a member of a group of three working under my guidance during the entire school year 1979/80 on an industrially-sponsored design project. They developed an electrically pulsed, high pressure water jet for selectively slicing vegetables, such as carrots. A prototype was built and tested, and the sponsor has since taken out a patent on the device.

Gerson is bright and has a very quick and fertile mind. He develops many creative ideas, too many for him to develop in detail. He works best under guidance from a senior and experienced person who can channel his creativity into useful and productive channels.

He is a personable and pleasant young man.



Position of writer Professor (Signed) Ernest G. Chilton

Organization Mechanical Engineering, Design Div. Type or Print Name Ernest G. Chilton

City and State Stanford, CA 94305 Date 10/5/81

Return to CAREER PLANNING AND PLACEMENT CENTER, STANFORD UNIVERSITY, STANFORD, CALIF. 94305