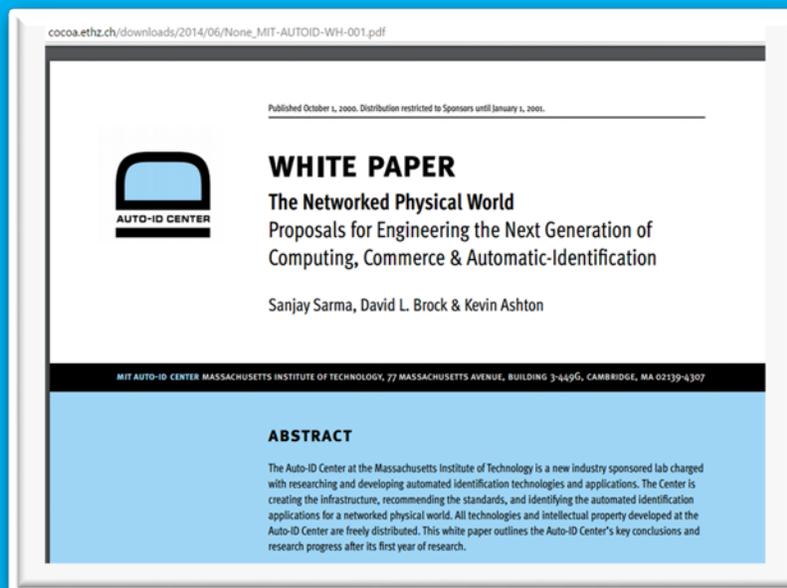MIT Auto-ID Labs initiative to extend Auto-ID Center ideas which catalyzed RFID systems and germinated the concept of IoT in 1999. AIDL's IoT Collaborative Research Initiative (ICRI) expects to build on the Cloud of Things ideas and engage with an even broader "binary" vision where invention and innovation may advance digital transformation through engineering design. Research related to IoT by design may enhance industrial internet of things. We invite ideas to stimulate research necessary for new tools and technologies. IoT use in diverse verticals (energy, healthcare, manufacturing, robotics, analytics, security) must address fundamental questions about connectivity, data and how systemic IoT by design may drive social entrepreneurship. We expect collaborative research to induce creative convergences while fully embracing innovation uncertainty.

R&D for IoT / IIoT System of Systems including Autonomy, Algorithms, Analytics, Connectivity and Security
IoT ideas - MIT Auto ID Center http://cocoa.ethz.ch/downloads/2014/06/None_MIT-AUTOID-WH-001.pdf

cocoa.ethz.ch/downloads/2014/06/None_MIT-AUTOID-WH-001.pdf

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AUTO-ID CENTER

WHITE PAPER
The Networked Physical World
Proposals for Engineering the Next Generation of
Computing, Commerce & Automatic-Identification

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ABSTRACT

The Auto-ID Center at the Massachusetts Institute of Technology is a new industry sponsored lab charged with researching and developing automated identification technologies and applications. The Center is creating the infrastructure, recommending the standards, and identifying the automated identification applications for a networked physical world. All technologies and intellectual property developed at the Auto-ID Center are freely distributed. This white paper outlines the Auto-ID Center's key conclusions and research progress after its first year of research.

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Our academic-industry initiative aims to structure bridges between researchers and partners. We aim to design and pursue research collaborations which may help resolve fundamental problems or create solutions to problems involving (but not limited to) identification, location, connectivity, analytics as well as the concept of IoT as a design metaphor in consumer or industrial internet of things deployments.

METHOD – This serves only as a guide and is neither binding nor limiting (leaving room for creativity)

Using the very broad diversity of academic research at MIT and the multitude of fundamental problems that may be acting as barriers to the progress of technology, we shall engage with industries keen to identify problems which require creative research-based elements and innovative R&D as a part of the potential solution set. We expect to work with nations and national agencies, as well as governments.

We propose to exclude problems/projects that may be handled by commercial consulting firms or are low hanging fruits seeking low level skills or devoid of challenge. The number and type of problems may be limited due to funding constraints from members and sponsors but our interests include location data, identification, networks/connectivity, transportation/aviation, manufacturing/robotics, healthcare/HIT, finance/fintech, energy and agriculture. There are no limits to the trans-disciplinary research areas or approaches, diversity of tools and vast array of technologies we may use or integrate or improvise or invent or innovate, in order to fuel creativity or contribute R&D to parts of a potential solution set(s).

Once we identify a research area (mesh networks, small cells, platforms, AI, data, analytics, healthcare interoperability) we dissect and discuss the elements with sufficient granularity to map the minutiae with our partners. This is the research team formation phase where we engage with the partners (or members / sponsors) and align the research needs and "unknowns" with faculty and researchers who may be able to contribute relevant R&D. The design of research is a critical phase in the engagement.

SCOPE – This serves only as a guide and is neither binding nor limiting (leaving room for creativity)

The member(s) contributing the problem, ie, the research-seeking partner (R&D partner) will decide whether to engage with the design of research suggested by the researchers through our Initiative (ICRI). The type and extent of research collaboration between industry partners and research teams are to be decided case by case. Industry may or may not participate on-site in the daily research conducted at MIT. Digital transformation is very diverse and research designs may change. Financial support for research originates from R&D partners. The amount of support will vary from case to case depending on the scope of research, duration, expected outcomes and the qualifications of the research personnel in the team.

Business-facing business solutions (B2B) are less and less profitable if sold as separate packages (ERP, sensors, database, analytics, visualization, mobility). Consumer-facing businesses (B2C) and B2B are increasingly demanding secure mobility for operations. The profit taking may be only at the "end of the tunnel" based on the value of analytics at the edge (point of contact is the monetization moment of truth).

Behemoths may try but are increasingly impotent to provide the end-to-end spectrum of solutions which must use one or more platforms to acquire, aggregate, synthesize, stitch, analyze, connect and respond. Partnerships (Apple + Cisco, GE + Huawei, Samsung + UCSF) are springing up to supplement critical need for system of systems (systems engineering *modus operandi* for business/industry). This is an old concept in academia but a difficult process for industry, especially when the behemoths must work with small businesses (SMEs) or start-ups to complete the value chain necessary for their systems integration. Imminent tsunami of changes are breaking down the immanent silos of IT (information technology), OT (operations technology) and tele-communications. Patch-work of systems create even more problems.

The haphazard patch-work quilt in the business world is driven by the lack of tools and technologies which are unlikely to be unleashed without systemic research. The vision of recombinant innovation is an attractive marketing juxtaposition of words but it remains poorly substantiated without new tools, new technologies, new ideas, new concepts, new theories and new solutions based on new research. IoT Collaborative Research Initiative (ICRI) aims to focus on areas where new research and synthesis with trans-disciplinary R&D may offer clues to potential solutions. We aim to advance the concept of IoT as a design metaphor (digital-by-design) and offer research assistance to catalyze digital transformation.

Why?

IoT is a "digital-by-design" metaphor. Applying this concept to create connectivity solutions calls for research. System of systems interoperability and system-specific platform integration (with functions such as cybersecurity, protocol-agnostic application-triggered connectivity, business logic, customer applications, visualization, data receivers/transmitters, actuators, analytics, intelligence, AI) in diverse verticals are fraught with problems because of known unknowns and unknown unknowns. This quagmire needs to be addressed and research is one answer (but it is not a panacea for all problems).

Where?

We are creating an initiative in an institution with credibility and where the concept of IoT germinated in 1999 (MIT Auto ID Center). The research necessary to advance these trans-disciplinary ideas requires collaboration and freedom from the boundaries of conventional academia immersed in monolithic silos. We use the collaborative academic ethos at MIT to access the research ecosystem. We aim to develop necessary liaison which highlights brilliance, excellence, original vision and unquestionable scientific credibility. Sponsors, members and research partners of ICRI are expected to help the mission of ICRI and collaborate with MIT, MIT Auto-ID Labs, ICRI and our extended liaison in the pursuit of R&D excellence.

Who?

[1] Industry representing verticals (telco, transport, health, manufacturing, robotics, energy, finance)
[2] Institutional excellence as a "draw" to build the team of partners and researchers to pursue projects

How?

Multi-pronged approach gradually phased to reduce the barrier to entry and commencement of research

Phase I (1-6 months but subject to change - serves only as a guide and is neither binding nor limiting)

[1] Establish agreement with ICRI
[2] Suggest problem / discuss to create research team
[3] Arrive at a design of research plan
[4] Agree on a plan and cost (invest)

Phase II (7-24 months but subject to change - serves only as a guide and is neither binding nor limiting)
[1] Commencement of collaborative research / monitor, adapt, evolve (repeat)
[2] Link research / understand points of potential integration / gap analysis
[3] Connect gaps with other types of research activities (or terminate project)

Phase III (25-36 months but subject to change - serves only as a guide and is neither binding nor limiting)
[1] Deploy research / proof of concepts functional tests / evaluation using internal and external experts

What?

[1] ICRI at MIT and other experts may meet with members to identify / dissect or diagnose problems and isolate research areas / topics which could determine the composition of research team. The team drafts and discusses the design of research to address the topics identified in collaboration with the partner(s).

[2] ICRI may occasionally host workshops for members to communicate significant research advances which may catalyze industry members to consider a new line of exploration and stimulate new research to explore further. For example, members from the manufacturing/robotics field may own thousands of machine tools which cannot be replaced but these disconnected objects are crying out for advancement to the next generation of industrial IoT. How? What fundamental elements are missing? Can research uncover one or more tools and technologies to overcome the insurmountable barriers preventing the convergence of IT, OT and telco (protocol-agnostic telecommunications)?

[3] ICRI may grow an Advisory Board (year 1-3) to reflect a broad spectrum constellation of academic and industry experts who may guide the ICRI vision of collaborative research. We may deploy the credibility of experts (Advisory Board) to offer leadership services (summer studies) and explore future points of convergence and/or consider engaging in or driving global architectures or standards activities.

[4] ICRI seeks visionaries who believe in the power of research to unlock economic potential. As a part of the team, sponsor, members and partners may share their vision and also exemplify the perseverance that research demands. One must be comfortable in embracing innovation uncertainty and assume risk of leadership that research demands (in order to reap the harvest from outcomes which may be profitable).

[5] ICRI may use its global network and liaison to promote research through grant applications (funding).

[6] Engagement with research is the cornerstone of ICRI at MIT Auto-ID Labs and our extended liaison. Creative mechanisms to engage, enhance and support excellence in research is the primary priority for MIT as an institution for higher research. The commercialization of R&D and related business consulting is not an integral part of this R&D initiative but may be pursued through other excellent mechanisms available, eg, MIT Engine (http://news.mit.edu/mit-announces-the-engine-for-entrepreneurs-1026).

[1] ICRI seeks sponsors and members to support this initiative (range $10,000 to $10,000,000+ pa as tax exempt contribution to MIT, 501c(3) non-profit organization] to drive the momentum for thought leadership, cross-pollinate ideas and usher diverse lines of research to serve broad spectrum of domains. Sponsors and members may take part in the operation of ICRI (TBD) perhaps through the organizational frameworks (Advisory Boards, various sub-committees and working groups) or other structures which may be involved with promoting thought leadership activities, education as well as advancing research.

[2] Your contribution enables you to [a] engage as a member of ICRI, [b] participate in various forums for members to provide exposure to research at MIT or sharing problems from the field, [c] interacting with a broad spectrum of stakeholders in many domains (national and international, foreign and domestic, local and global) and [d] creating research collaborations or coalitions to apply for research funding.

[3] ICRI may initiate or be a part of proposals to research agencies (NSF, DARPA, DoD, DoE, H2020). These are research dependent. The academic research platform at MIT will be quintessential to facilitate the process of creating coalitions and collaborations. Sponsors, members and partners may wish to collaborate, if they offer highly qualified and eligible personnel for research project proposals who can exceed the stringent criteria set by MIT and the funding agencies (to be included as a named sub-contractor) with an institutional principal investigator (PI). ICRI may act as a catalyst to connect the parties and stimulate discussion for proposals and/or collaborations for proof of concepts and/or large scale test beds, if necessary, as a part of the funding. Eligibility and disbursement of funds are regulated by funding agencies and established guidelines from the Office of Sponsored Research (OSP) at MIT.

[4] R&D partners engaged in collaborative research projects will find that cost of research at MIT depends on items described in the proposed budget. The latter depends on the nature of the research, strengths and skills of the personnel required, duration of the project and other factors, eg, overhead. It is a project-specific discussion. Research at MIT carries with it an unique seal of excellence and credibility.

[5] Members may request to explore specific activities including digital education in IoT, curated executive education or other types of engagement or advisory (at additional cost, decided case by case).

[6] Fiscal differentiation of the terms - sponsors, partners and members - are outlined. Other categories may be created (if needed) in response to other types of activities related to research or leadership.

[I] SPONSORS

Sponsors play a pivotal role to advance the strategic mission of research to benefit civilization. Leaders who believe in the mission of research at MIT and willing to help us to further the benefits of science for society. Sponsors may choose to financially support MIT Auto-ID Lab's initiatives (ICRI) toward global progress in digital transformation. Sponsorship amounts are not set in stone but suggested range may extend from $100K to $100M or more. Benefits may not be described as deliverables (as on a BOM or bill of materials) but sponsors may expect to:

[1] learn about ongoing research at MIT in terms of potential for future research engagement

[2] participate in think tank activities for cross-pollination of ideas, redefine conventional wisdom, stimulate new avenues for trans-disciplinary confluence, catalyze the role of education in communities

[3] stimulate exploration of topics/ideas, known or unknown, which may be relevant or benevolent to enlighten life and augment socio-economic growth through the mission of education and research

[4] identify creation of strategic alliances through existing opportunities or fund entirely new efforts.

[II] MEMBERS

Members are participants who may wish to invest in the general mission of research but may not be ready to commit to major efforts. Members may be in the pre-phase to research. They may attempt to mentally synthesize or connect the dots presented by the vast potential of the MIT "innovation machine" and try to identify areas/ideas which may segue to potential research partnership with ICRI. Annual membership dues are suggested to be $10K with the range set from $10K to $100K. Some of the benefits of membership may include:

[1] awareness about ongoing research at MIT from various forums

[2] exposure to meetings, seminars and conferences

[3] discuss potential / exploratory research topics

[4] membership precedes research partnership

[III] PARTNERS – PARTNERSHIPS

The designation "partners" is reserved for members or sponsors who may actively engage with us on specific research pursuits. We aim to keep enough room for creativity and understanding to chart a mutually acceptable *modus operandi* across nations, cultures and interests, in order to enable you to design and justify the funding and investment at MIT for research. An outline is suggested as follows:

[01] Please send us a brief but specific indication of research topics of interest. You make request NDA.

[02] We will respond with suggestions relevant to your interest and may also include other topics.

[03] We shall discuss our exchange and try to search for common grounds, overlap or path forward.

[04] If we arrive at a mutually productive set of research ideas / topics then we plan your visit to MIT.

[05] Prior to your visit you shall send us information about your team members and/or their research. We will exchange information about the plan du jour and meetings at MIT with specific research teams. If we agree on the team and the plan du jour then we focus on logistics, date, time, arrival and departure.

[06] The expected outcome of your visit to MIT is a tentative sketch of the potential research direction that you feel you wish to pursue after the face to face exchange. Lack of agreement between your research interest and MIT team may set you back to step [3] or you/we may terminate the exploration.

[07] If a mutually acceptable research direction evolves from step [6] then you may provide us with a more detailed statement of work including your expected outcomes in the next 2-4 weeks after the visit.

[08] MIT research team members will respond to your SOW with respect to content (may edit, modify) as well as expectations, duration, personnel and estimated cost by category for sponsored research at MIT.

[09] If you find the response suitable, you shall signal your intent to engage with MIT for the research.

[10] Using the research plan you have at hand (from step [8]), you may [i] engage with MIT research team if you wish to discuss details and [ii] engage with MIT OSP (Office of Sponsored Research) for the execution of contractual details and financial arrangements per pre-established MIT OSP guidelines.

[11] In the event you think the response from step [8] requires a further round of discussion, you may request the MIT research team to re-visit the problem (re-do [8]) but their acceptance is not guaranteed.

There may be a general opinion in the industry that IoT is not a research topic but in its implementation phase. This is not incorrect but suffers from the constricted perspective predominant in the market. It is the view of IoT as a "thing" or application which is common and prevalent both in the industrial as well as consumer centric approaches.

The operational implementation of IoT is one part of the concept. The latter is the domain of industry and groups or consortia. The spread of "IoT" as wildfire is an outstanding stroke of marketing and the genius of PR which has managed to catapult the term as a part of the daily vernacular, for the masses (for good).

IoT is a design metaphor. It is a concept which one can use loosely to embrace a very broad range of domains and applications. The naming (IoT) of these myriads of concepts housed under one term (IoT) may fail to do justice to the principles and practice of connectivity, which remains the foundational layer. The latter may include topics as diverse as qubits in computation to OFDM for networks and metal doped graphene for energy density or VR. I wouldn't conclude that qubits or OFDM like tools or VR or doping of graphene are research-depleted fields. Even more practical areas (5G, AI, blockchain) needs bit of R&D.

The R&D part of this design concept (which is of interest to us and other institutions of research), implicit in IoT, still lacks fundamental science and engineering issues, both known and unknown, waiting to be uncovered/discovered. From discovery to innovation and application necessitates the development of tools, protocols and standards to advance, adapt and adopt the technologies. Taken together, that is our intention and what we wish to pursue, in certain domains. A few elements of that "future" and clues to some of the research potential are described (imperfectly) for a few select topics in the pages below:

https://dspace.mit.edu/handle/1721.1/104429

https://dspace.mit.edu/handle/1721.1/106496

https://dspace.mit.edu/handle/1721.1/86935

http://autoid.mit.edu/iot_research_initiative

https://autoid.mit.edu/shoumen-datta