This keynote was presented at the Kent State University (KSU) Knowledge Science Center (KSC) symposia held in Canton, Ohio and Washington, DC. The purpose of these gatherings was to bring together delegates from different organizations and disciplines to contribute to the value architecture for a new Knowledge Science Center to be sponsored by Kent State University and others. Delegates collaborated to develop scenarios, define capability cases, and prioritize the most valuable services and best ways to engage stakeholders in government, industry, academia, professions, and civil society.

As the title suggests, this presentation focuses on three aspects of the Knowledge Science Center mission: knowledge science, concept computing, and intelligent cities.

The mission of knowledge science is transformation

- Transformation
- Knowledge
- Concept computing
- Intelligent cities

The thesis advocated by this talk is that the mission of knowledge science is transformation.

First, we start with an explanation of what we mean by transformation and why transformation should be central to the mission of the KSC.

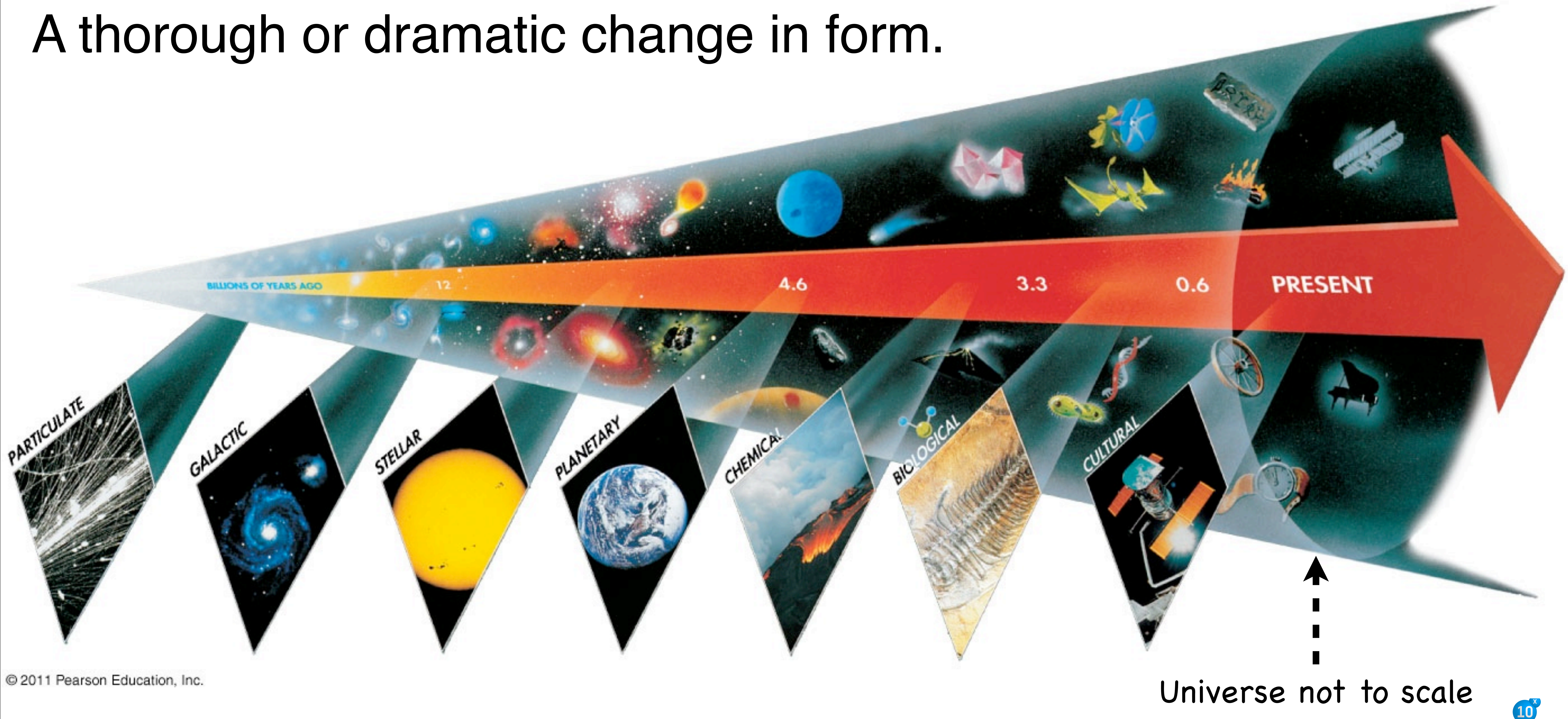
Second, we share some thoughts about what we mean by knowledge, and more specifically, a computational theory of knowledge.

Third, we overview the current state of knowledge technologies, and more specifically, the emerging paradigm we call concept computing.

Fourth, we discuss development of intelligent cities as a mission for the KSC whose significance is worthy of the journey. This discussion includes examples of how the synthesis of knowledge science, concept computing, and knowledge management can power the transformation of urban centers into intelligent cities.

What is the transformation?

A thorough or dramatic change in form.



What is transformation? A thorough or dramatic change in form. The point of the illustration is that it appears that transformation is and always has been a pervasive property of our universe.

Transformational changes demand different knowledge and changes in architecture.

Here is a little story to illustrate the point:

A scientist discovered a way to grow the size of a flea by several orders of magnitude. She was terribly excited. After all, a flea can jump vertically more than 30 times its body size. She reasoned that a flea this big would be able leap over a tall building. Perhaps, there could be a Nobel Prize in this.

When the day came to show the world, she pushed the button and sure enough out came this giant flea, over two meters high. But, rather than leaping a tall building, it took one look around and promptly fell over dead. Turns out it couldn't breath. No lungs. Passive air holes that worked fine for oxygen exchange in a tiny flea were useless for a creature so big.

Moral #1: Transformational change demands different knowledge and different architecture.

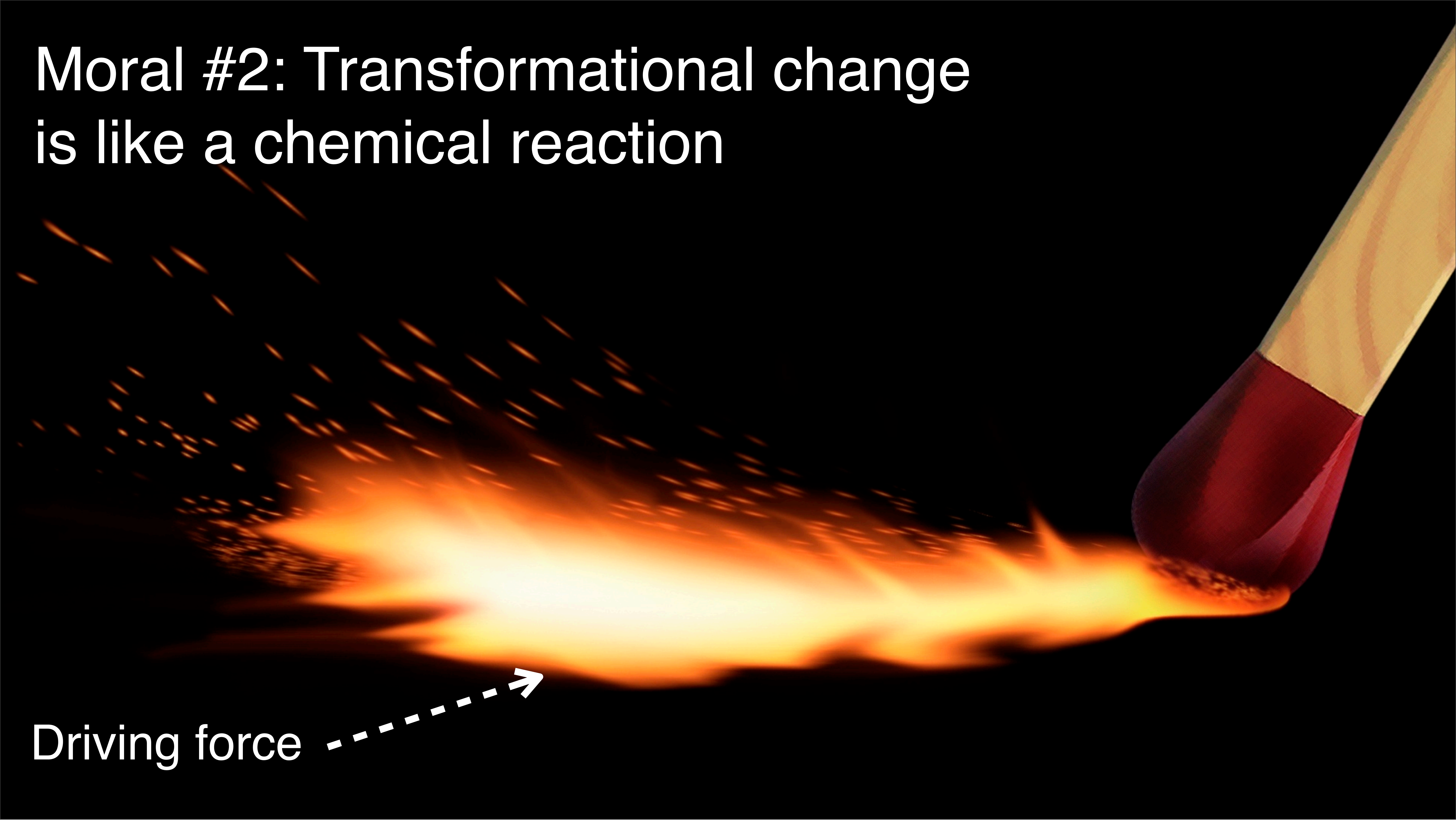
Moral of the story #1:

Transformational changes demand different knowledge and innovations in architecture.

Transformations associated with networks and computing come with significant changes in scale, complexity, connectivity, sense modalities, communication bandwidth, knowledge-intensivity of decision-making, execution speed, and environment.

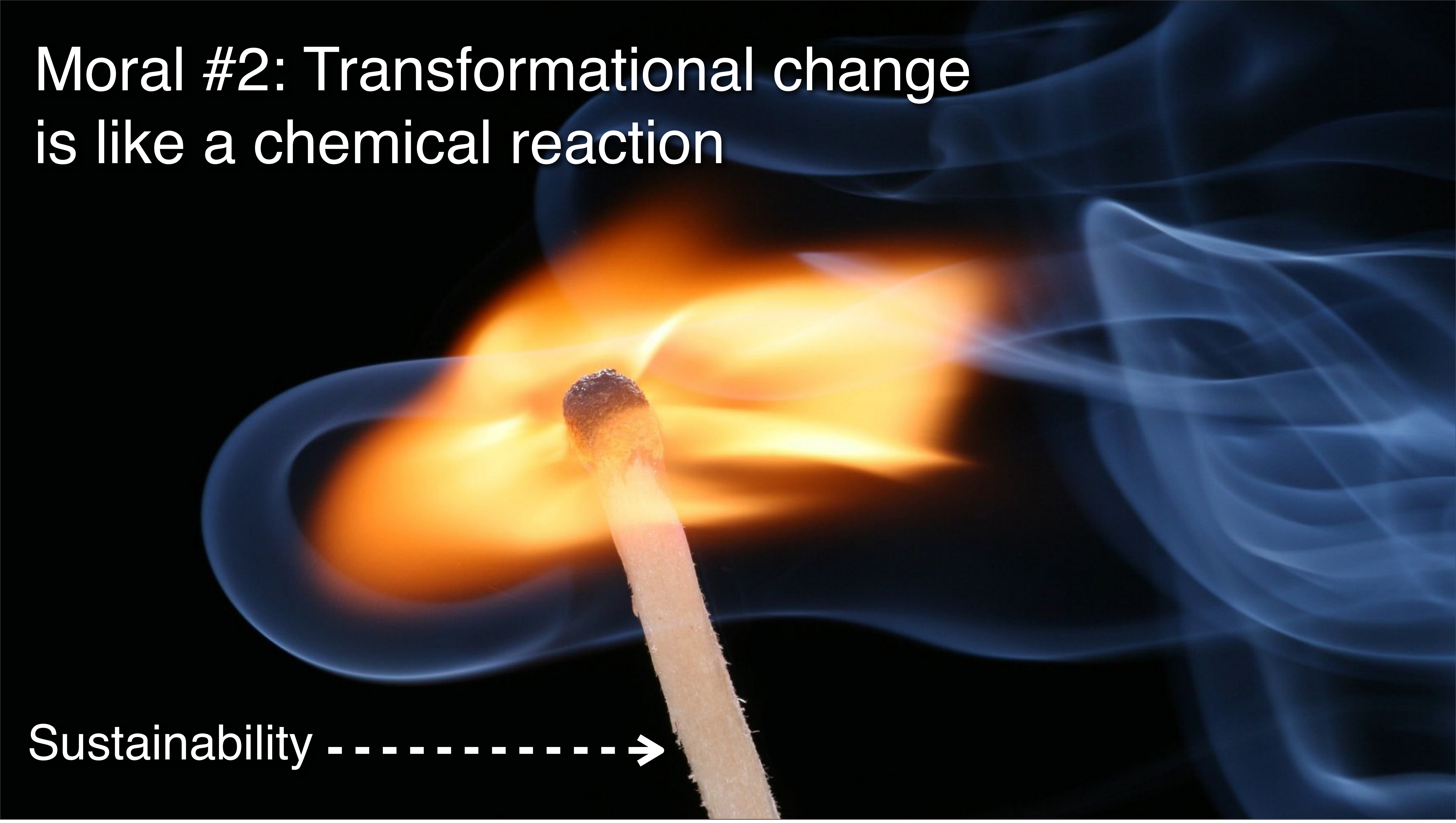
Moral #2:
Transformational change is like a chemical reaction. There is always an energy equation.

For example, to light a match, there is an energy of activation. You have to strike it.



Moral #2:
Transformational change is like a chemical reaction. There is always an energy equation.

Secondly, there needs to be a driving force. In this case, once ignited, the phosphorus releases enough energy that the reaction continues on its own.



Moral #2:
Transformational change is like a chemical reaction. There is always an energy equation.

Thirdly, there needs to be a source of enough fuel to keep the fire going. In this case, the match stick.

For transformation, huge drivers exist.

- Technologies that will change the world 1000X.
- Smart processes to power multi-trillion dollar economic expansions.
- 50X increases in knowledge worker productivity attainable by 2030.
- Intelligent cities competing to become vibrant cultural and economic centers.

This slide lists four huge drivers for transformation. We'll visit each of these points in the slides that follow.

The analogy of lighting the match applies to social, cultural, and economic transformations. These consume, liberate, and harness energies in new ways. Knowledge science, concept computing and knowledge management together are enablers of new categories of capability as well as new levels of performance. Like catalysts, they fundamentally reduce the "energy of activation," resources and time required to get there.

Knowledge = Theory + Information that reduces uncertainty

The next few slides discuss what we mean by knowledge as well as some basic ideas of a computational theory of knowledge.

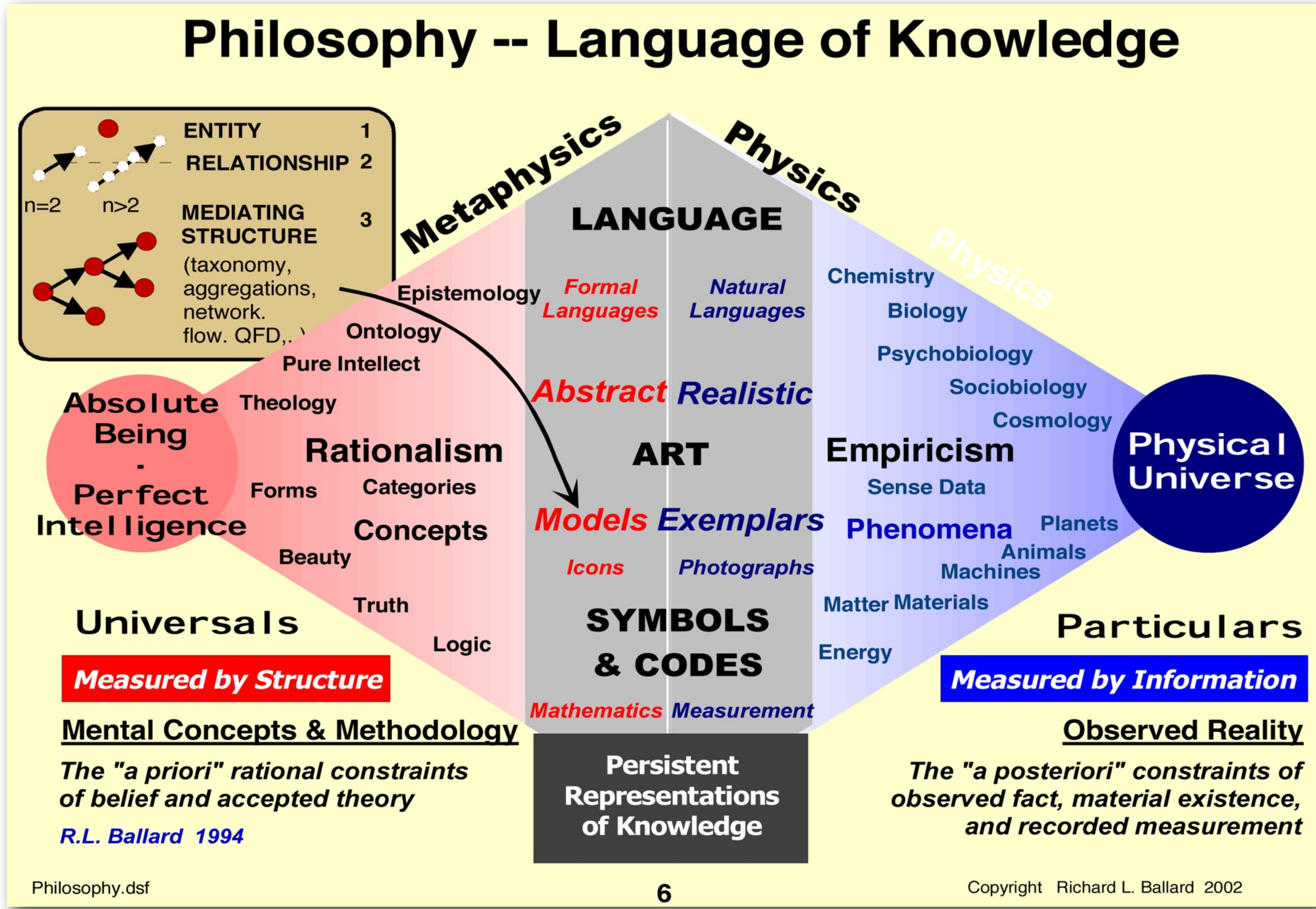
What is the scope of knowledge science?

Everything that has ever been thought or ever can be.

This diagram reflects a philosopher's traditional picture and our acquired definitions of knowledge.

On the right (in blue) are all observations and measurements of the physical universe, the facts that characterize reality -- past, present, and future. Within its bounds you find every object, every quantum of energy, every time and event perceived or perceivable by our senses and instrumentation. This situational knowledge of physical reality is “information” in the sense of Shannon. It is a world of singular and most “particular” things and facts upon which we might figuratively scratch some serial number or other identifying mark.

On the other side (in red) are all the “concepts” or ideas ever imagined -- by human's, by animals and plants, by Mickey Mouse, or a can of peas. We can “imagine” a can of peas thinking. It embraces every mode of visualizing and organizing and compelling the direction of our thoughts from logic to religion to economics to politics to every reason or rationale for making distinctions or for putting one thing before another.



“Knowledge is anything that resolves uncertainty. Knowledge is measured mathematically by the amount of uncertainty removed. Knowledge bases are defined by the questions they must answer.

Source: R.L. Ballard

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At the center, divided between physical and metaphysical (abstract) are in gray all the things and ideas used as representations or metaphors for something else -- physical sounds representing language; charts recording time, date, and temperature; pits burned in CD-ROMS; logs, journals, and history books. On the abstract side, we have alphabets and icons and equations and categories and models. Through these things we attempt to teach, to learn, to communicate, to record, to compute, to manipulate, and to integrate our knowledge of all things outside the limits of our own being and thinking and existence.

What is universal knowledge technology?

Knowledge = theory + information that reduces uncertainty.

As the next internet gains momentum, expect rapid progress towards a universal knowledge technology that provides a full spectrum of information, metadata, semantic modeling, and advanced reasoning capabilities for any who want it.

Large knowledgebases, complex forms of situation assessment, sophisticated reasoning with uncertainty and values, and autonomic and autonomous system behavior exceed the capabilities and performance capacity of current description logic-based approaches.

Universal knowledge technology will be based on a physical theory of knowledge that holds that knowledge is anything that decreases uncertainty. The formula is:

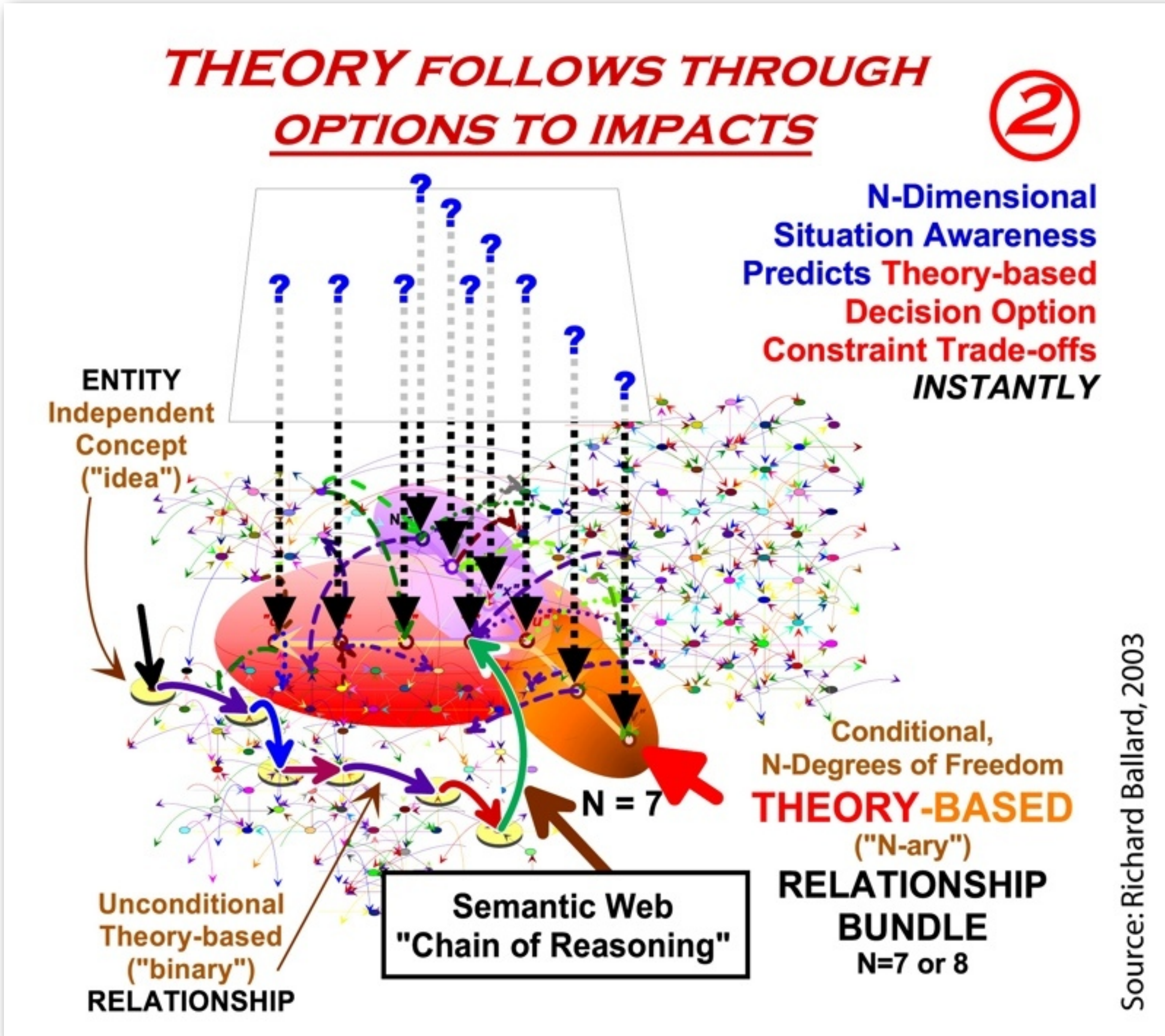
Knowledge = Theory + Information.

Theories are the conditional constraints that give meaning to concepts, ideas and thought patterns. Theory asserts answers to “how”, “why” and “what if” questions. For humans, theory is learned through enculturation, education, and life experience.

Information, or data, provides situation awareness — who, what, when, where and how-much facts of situations and circumstances. Information requires theory to define its meaning and purpose.

Theory persists and always represents the lion’s share of knowledge content — say 85%. Information represents a much smaller portion of knowledge — perhaps only 15%

What will distinguish universal knowledge technology is enabling both machines and humans to understand, combine, and reason with any form of knowledge, of any degree of complexity, at any scale.



Source: Richard Ballard

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What is theory?

Any conditional or unconditional assertion, axiom or constraint used for reasoning about the world.

A *theory* is any conjecture, opinion, or speculation. In this usage, a theory is not necessarily based on facts and may or may not be consistent with verifiable descriptions of reality.

We use theories to reason about the world. In this sense, theory is a set of interrelated constructs — formulas and inference rules and a relational model (a set of constants and a set of relations defined on the set of constants).

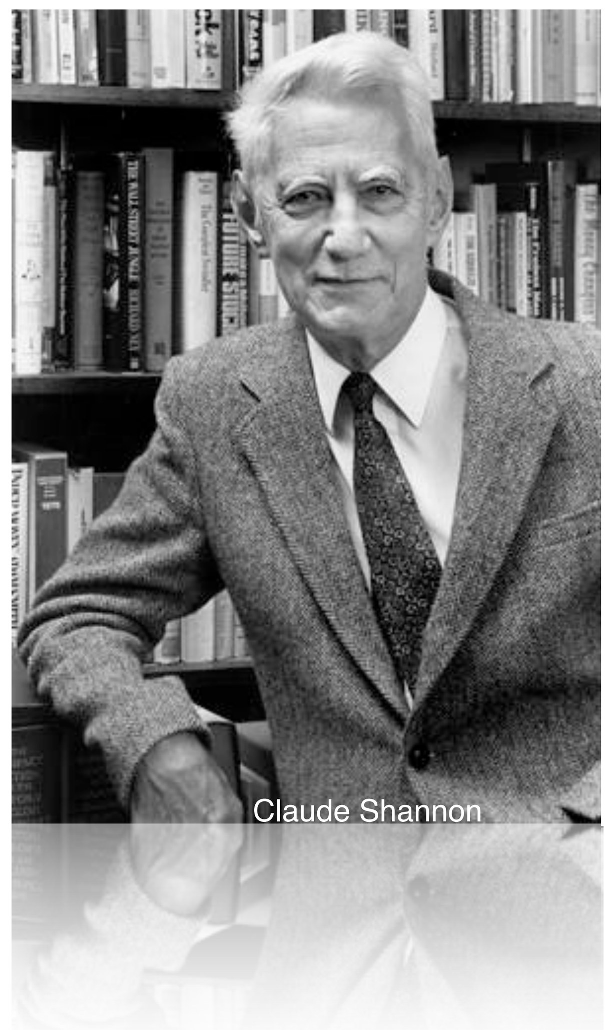
"The ontology of a theory consists in the objects theory assumes there to be."
-- Quine -- Word and Object, 1960

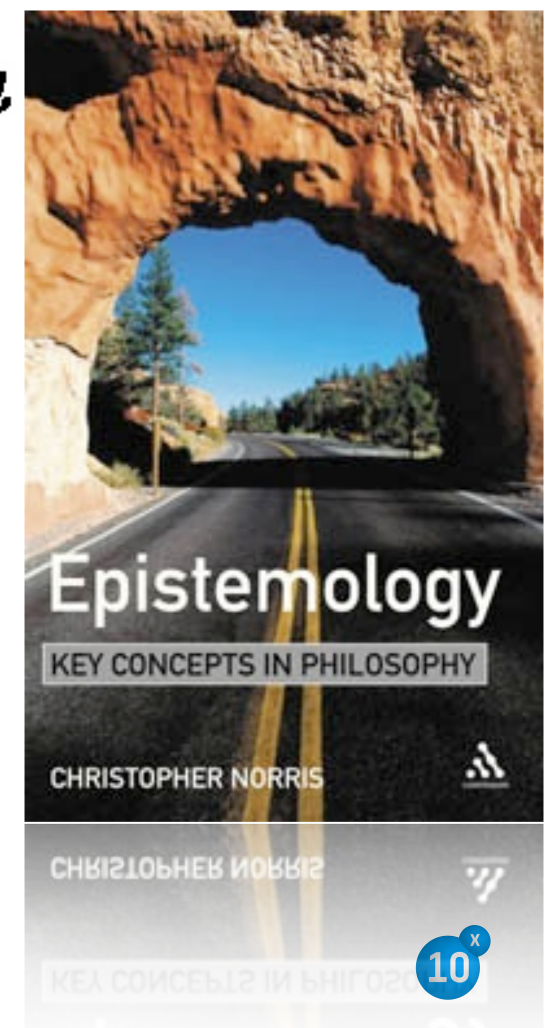
Theories are accepted or rejected as a whole. If we choose to accept and use a theory for reasoning, then we must commit to all the ideas and relationships the theory needs to establish its existence.

In science, theory is a proposed rational description, explanation, or model of the manner of interaction of a set of natural phenomena.

Scientific theory should be capable of predicting future occurrences or observations of the same kind, and capable of being tested through experiment or otherwise falsified through empirical observation.

Values for theory construction include that theory should: add to our understanding of observed phenomena by explaining them in the simplest form possible (parsimony); fit cleanly with observed facts and with established principles; be inherently testable and verifiable; and imply further investigations and predict new discoveries.





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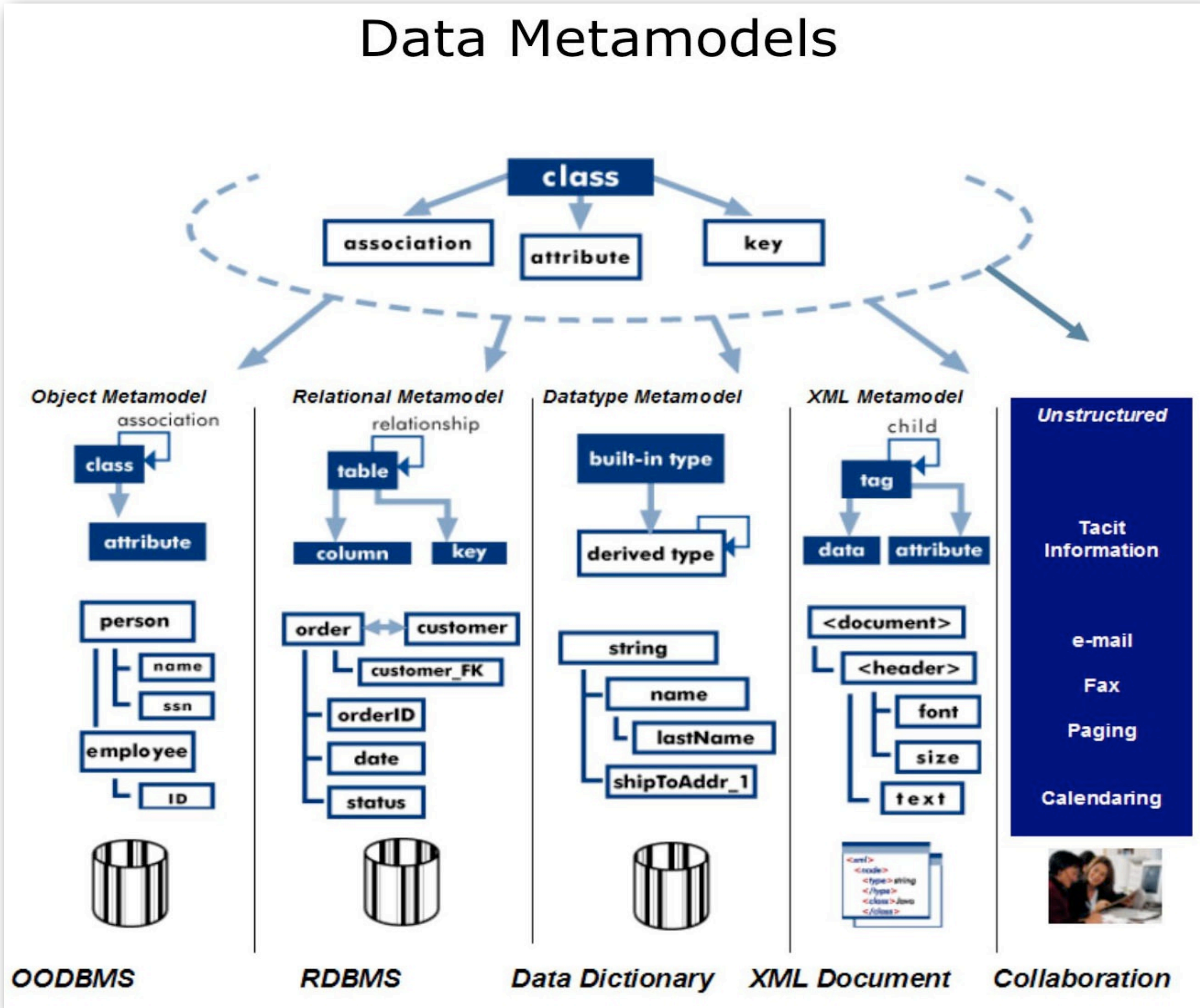
What are structured, semi-structured & unstructured information?

Types of data representation that semantic technologies unify.

Structured information is information that is understandable by computers. Data structures (or data models) include: *relational* — tabular formats for data are most prevalent in database systems, and operate best for storage and persistence; *hierarchical* — tree-like formats (including XML) are most prevalent in document models, and operate best in messaging systems (including SOA); and *object* — frame systems like Java and C# combine behavior with data encapsulation, and operate best for compiled software programs.

Semi-structured information is data that may be irregular or incomplete and have a structure that changes rapidly or unpredictably. The schema (or plan of information contents) is discovered by parsing the data, rather than imposed by the data model, e.g. XML markup of a document.

Unstructured information is not readily understandable by machines. Its sense must be discovered and inferred from the implicit structure imposed by rules and conventions in language use, e.g. e-mails, letters, news articles.



Examples of data models.

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What is value?

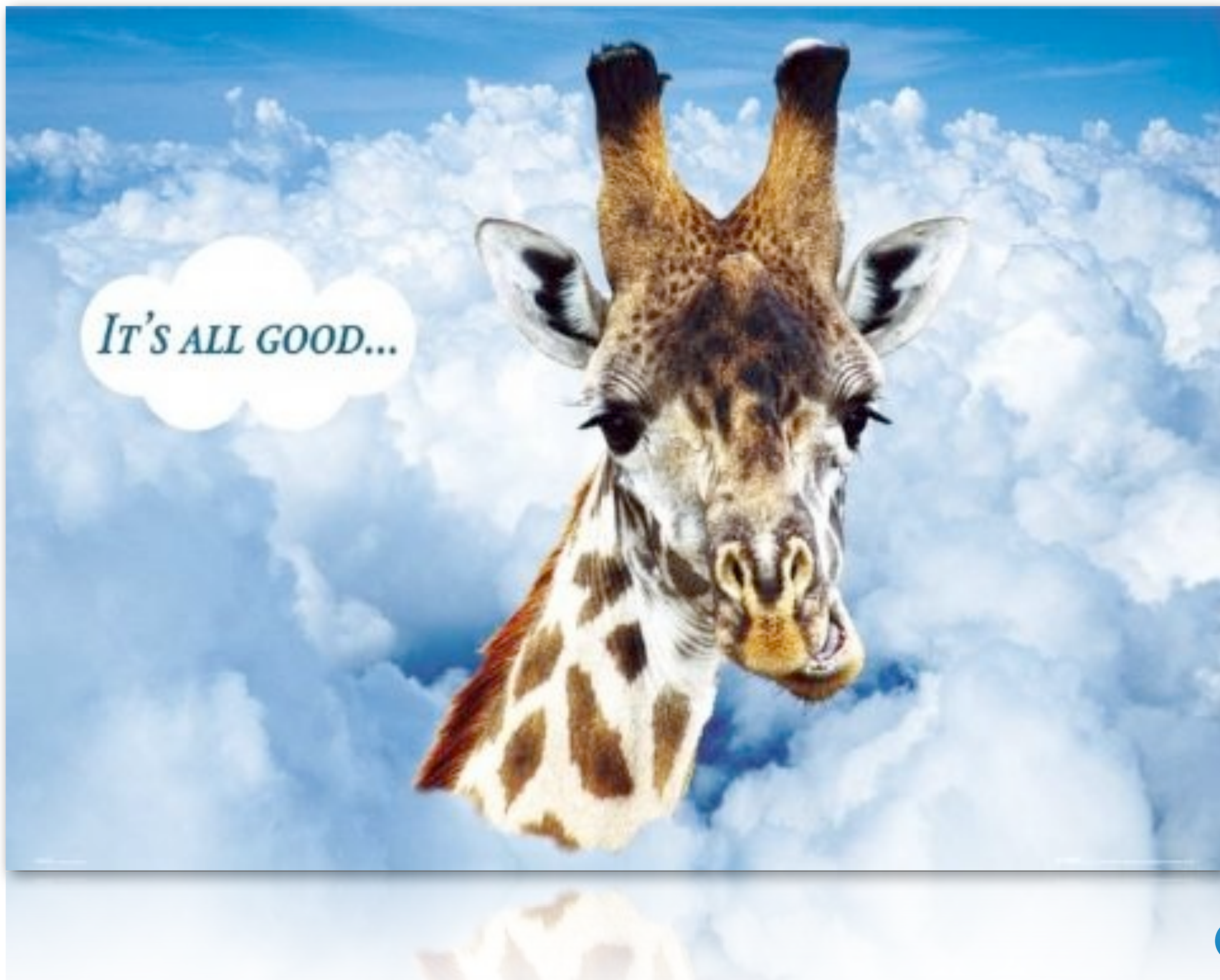
The measure of the worth or desirability of something.
The foundation of meaning.

Value is the foundation of meaning. It is the measure of the worth or desirability (positive or negative) of something, and of how well something conforms to its concept or intension.

Value formation and value-based reasoning are fundamental to all areas of human endeavor. Theories embody values. The axiom of value is based on “concept fulfillment.”

Most areas of human reasoning require application of multiple theories; resolution of conflicts, uncertainties, competing values, and analysis of trade-offs. For example, questions of guilt or innocence require judgment of far more than logical truth or falsity.

Axiology is the branch of philosophy that studies value and value theory. Things like honesty, truthfulness, objectiveness, novelty, originality, “progress,” people satisfaction, etc. The word ‘axiology’, derived from two Greek roots 'axios’ (worth or value) and ‘logos’ (logic or theory), means the theory of value, and concerns the process of understanding values and valuation.



Source: Robert Hartman, David Mefford, Mills Davis

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What is knowledge representation?

Application of theory, values, logic, and ontology to the task of constructing computable patterns of some domain.

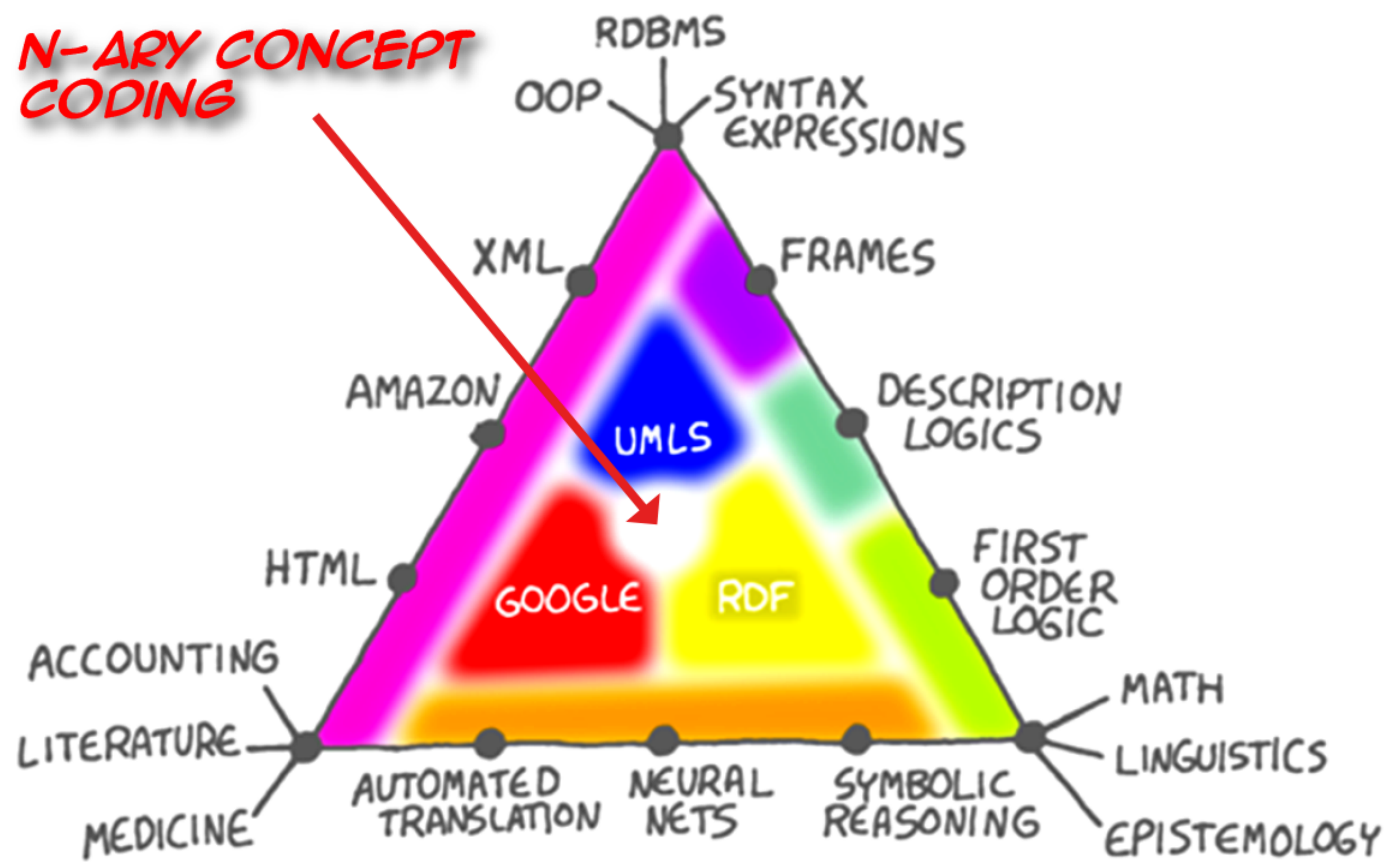
Knowledge representation is the application of theory, values, logic and ontology to the task of constructing computable models of some domain. Knowledge is "captured and preserved", when it is transformed into a perceptible and manipulable system of representation.

Systems of knowledge representation differ in their fidelity, intuitiveness, complexity, and rigor. The computational theory of knowledge predicts that ultimate economies and efficiencies can be achieved through ***variable-length n-ary concept coding and pattern reasoning*** resulting in designs that are linear and proportional to knowledge measure.

"Semantic networks" (entity-relationship) are the most powerful and general form for knowledge representation. They model knowledge as a nodal mesh of mental concepts and physical entities (boxes, circles, etc.) tied by constraining relationships (arrows, directed lines). Relationships describe "constraints" on concepts including: (a) logical constraints -- prepositions of direction or proximity, action verbs connecting subject to object, etc., and (b) reality constraints -- linking concepts to their time, image, attributes, or perceptible measures.

Physical knowledge is Information, or the a posteriori constraints of spatial-temporal reality. It includes sense data / measurements, observed or recorded independently — often dependent on time, place or conditions observed. Information representations include: numbers and units, tables of measurement, statistics, data bases, language, drawings, photographic images.

Metaphysical knowledge is rational structure, or the a priori constraint of mental concepts & perceived relationships, dictated by axiology, accepted theory, logic, and conditioned expectation — expressed as truth, correctness, and self-consistency — usually independent of time, place, or a particular reality. Representations include computer programs, rules, E-R diagrams, language, symbols, formula, algorithms, recipes, ontologies.



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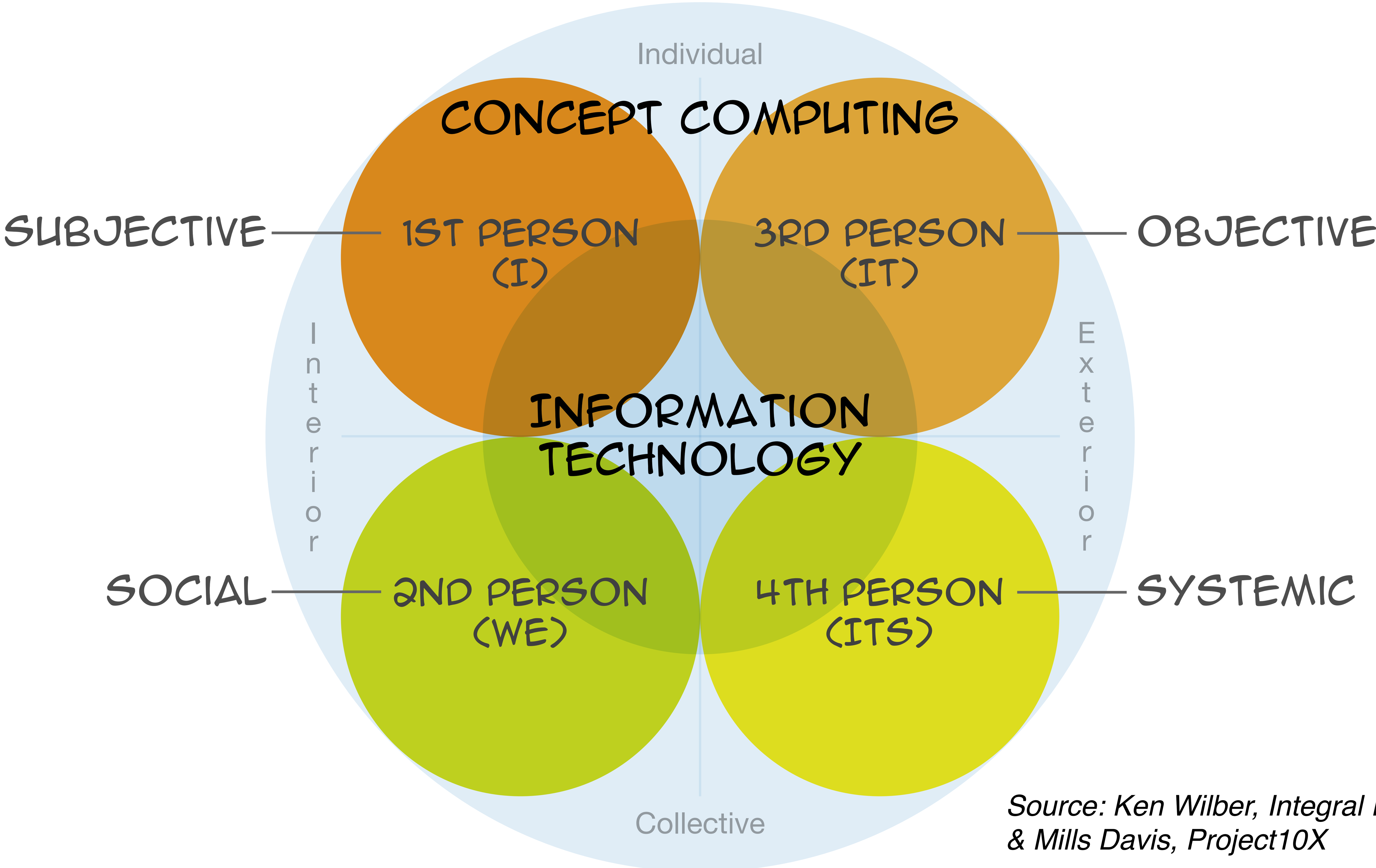
What is the integral perspective?

A key to integrating knowledge of different domains.



Source: Ken Wilber, Integral Institute & Mills Davis, Project10X

What is the integral perspective?
A key to integrating knowledge of different domains.

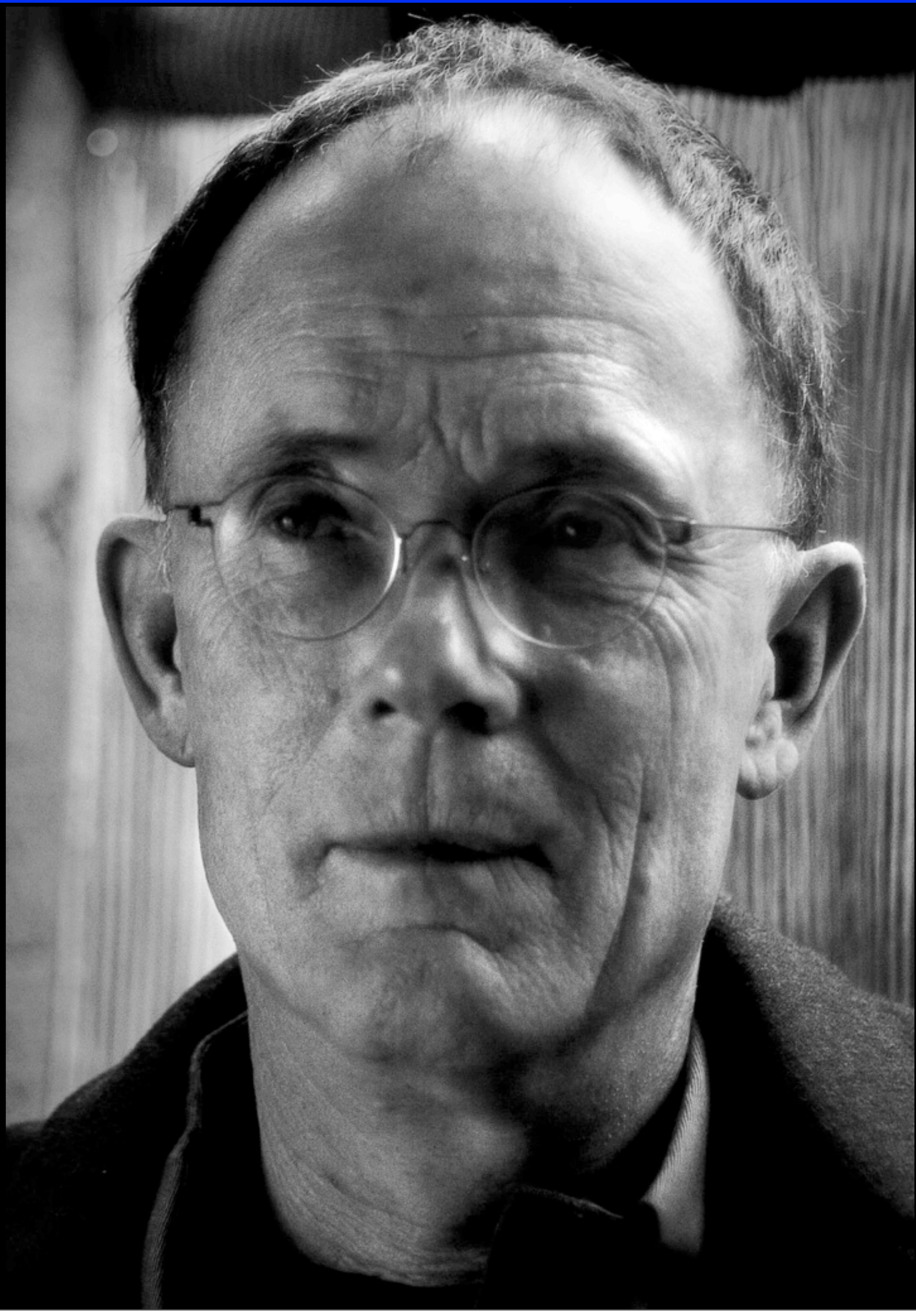
This quadrant diagram depicts four perspectives key to the evolution of knowledge science and concept computing products and services. Each quadrant gives rise to different modes of investigation, truth claims, and epistemological tests.

I — Subjective: the “I” in UI, how I experience things, the demands on my attention, focusing on my personal values, thoughts, emotions, memories, states of mind, perceptions and immediate sensations.

WE — Intersubjective: the “we” in web, social computing, our lived culture, shared values, language, relationships, cultural background, & how we communicate.

IT — Objective: The world of individual things viewed empirically, anything you can see or touch or observe in time and space; like product structure & behavior.

ITS — Interobjective: the world of systems and ecosystems, networks, technology, government, and environment(s).



“The future is already here. It’s just not very evenly distributed.”

William Gibson

Next, I want to talk about a new paradigm for computing, communications and knowledge. It’s a synthesis of a number of ingredients that have been percolating for a while now. We call it “concept computing.”

As Bill Gibson says, this future is already here. It’s just not very evenly distributed.

We’re accelerating towards an Internet of hundreds of billions subjects, services and things.

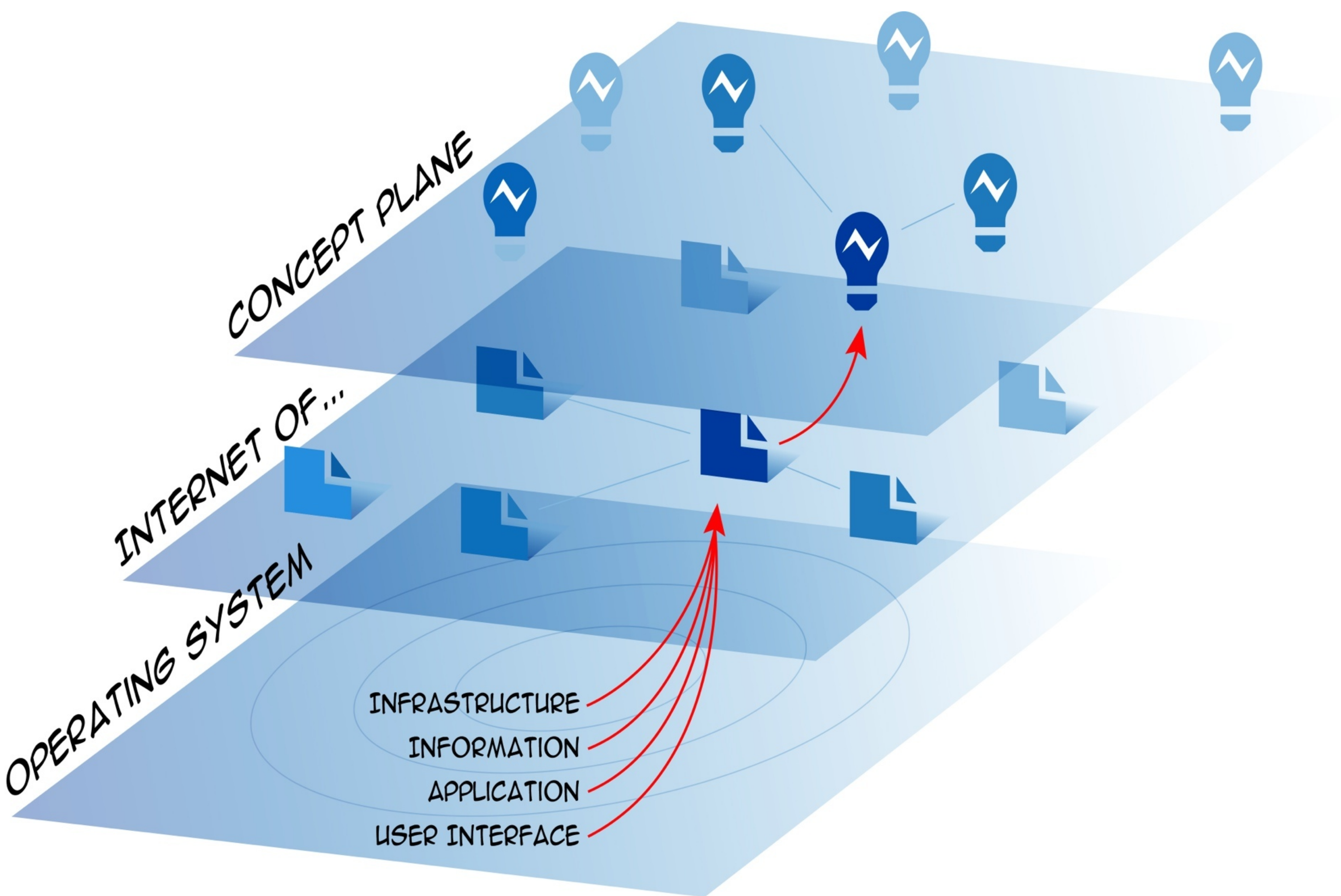
We’re not going to get there with conventional IT.

We need a technology that understands meanings and computes directly with knowledge models.

Concept computing!

What is concept computing?

Paradigm shift from information-centric to knowledge-driven patterns of computing.



Concept computing paradigm is a:

- Synthesis of AI, NLP, semantic, model-driven, mobile, and user interface technologies.
- Solution architectures where every aspect of computing is semantic and directly model-driven.
- Development methodology where every stage of the solution lifecycle becomes semantic, model-driven & super-productive.
- Spectrum of knowledge representation and reasoning, from search to knowing.
- Domain of connected intelligences where value multiplies.

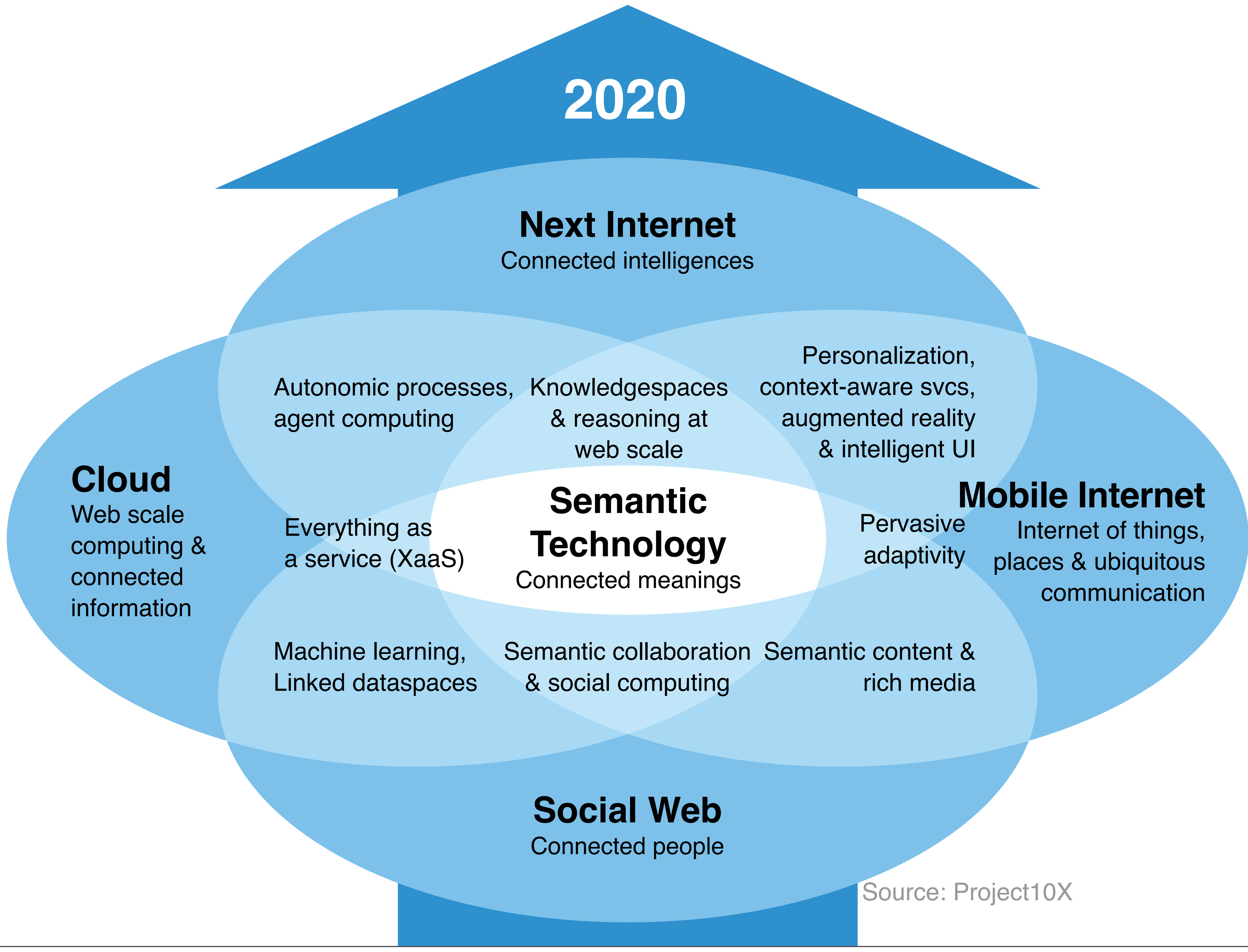
The basic IT stack has user interface, application, information, and infrastructure layers.
The internet has overlaid this with point and click network access to subjects, services, and things.

Concept computing takes the next step. A concept plane interconnects and enables reasoning across all layers of the IT and internet stacks.

Concept computing represents and processes knowledge about domains, user interface, application functionality, processes, information, and infrastructure separately from the underlying IT systems and other artifacts so that both people and computers can interpret concepts and put this knowledge to work.

What technologies are driving evolution concept computing?

Web, cloud, mobility, social, semantic, perceptive, and AI.

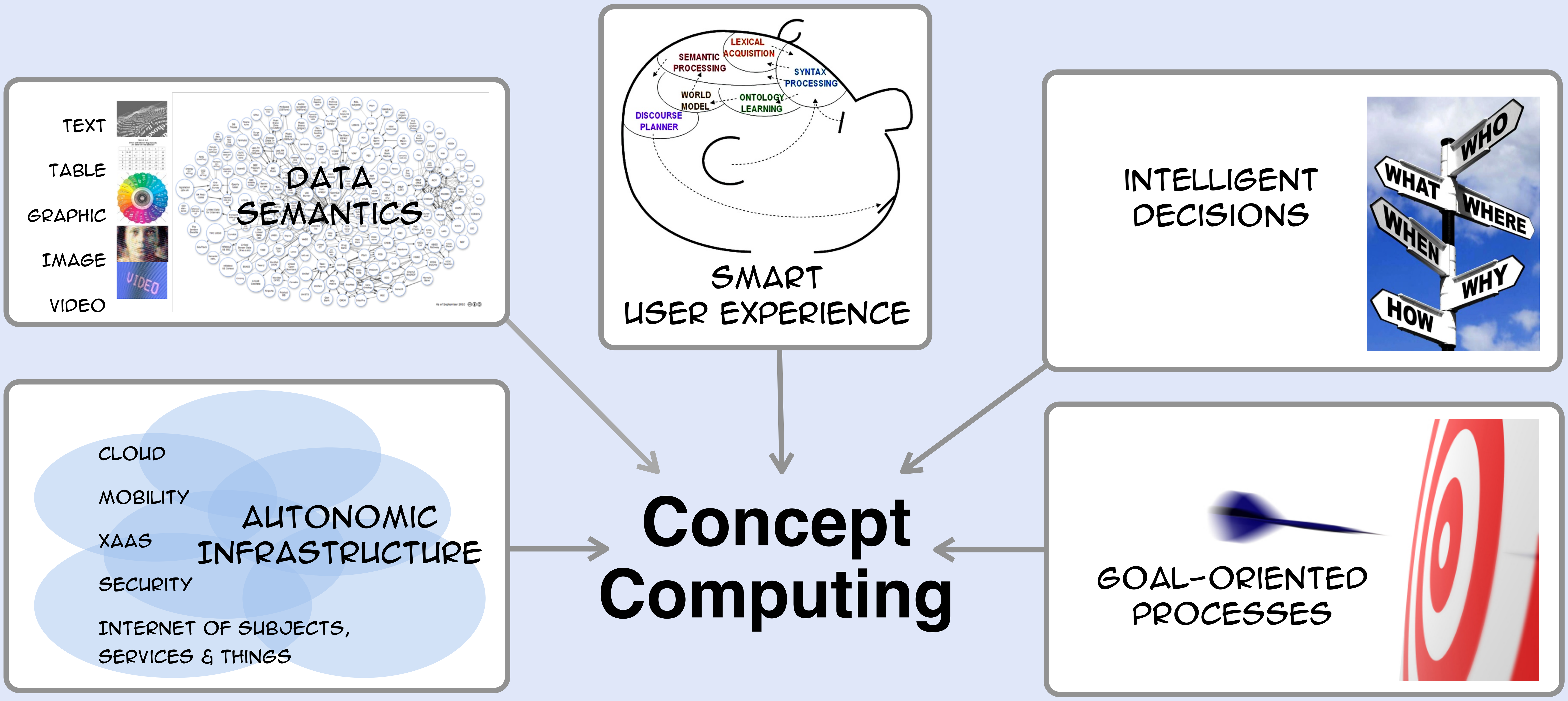


Source: Project10X

This venn diagram illustrates intersections and convergence of technologies that are driving the next internet and the emergence of the concept computing paradigm.

What makes concept computing different from conventional IT?

Every aspect of the solution is semantic and directly model-driven.



This diagram depicts five aspects of concept computing that we discuss further in the slides that follow.

Smart user experience
Data semantics
Intelligent decisions
Goal-oriented processes
Autonomic infrastructure

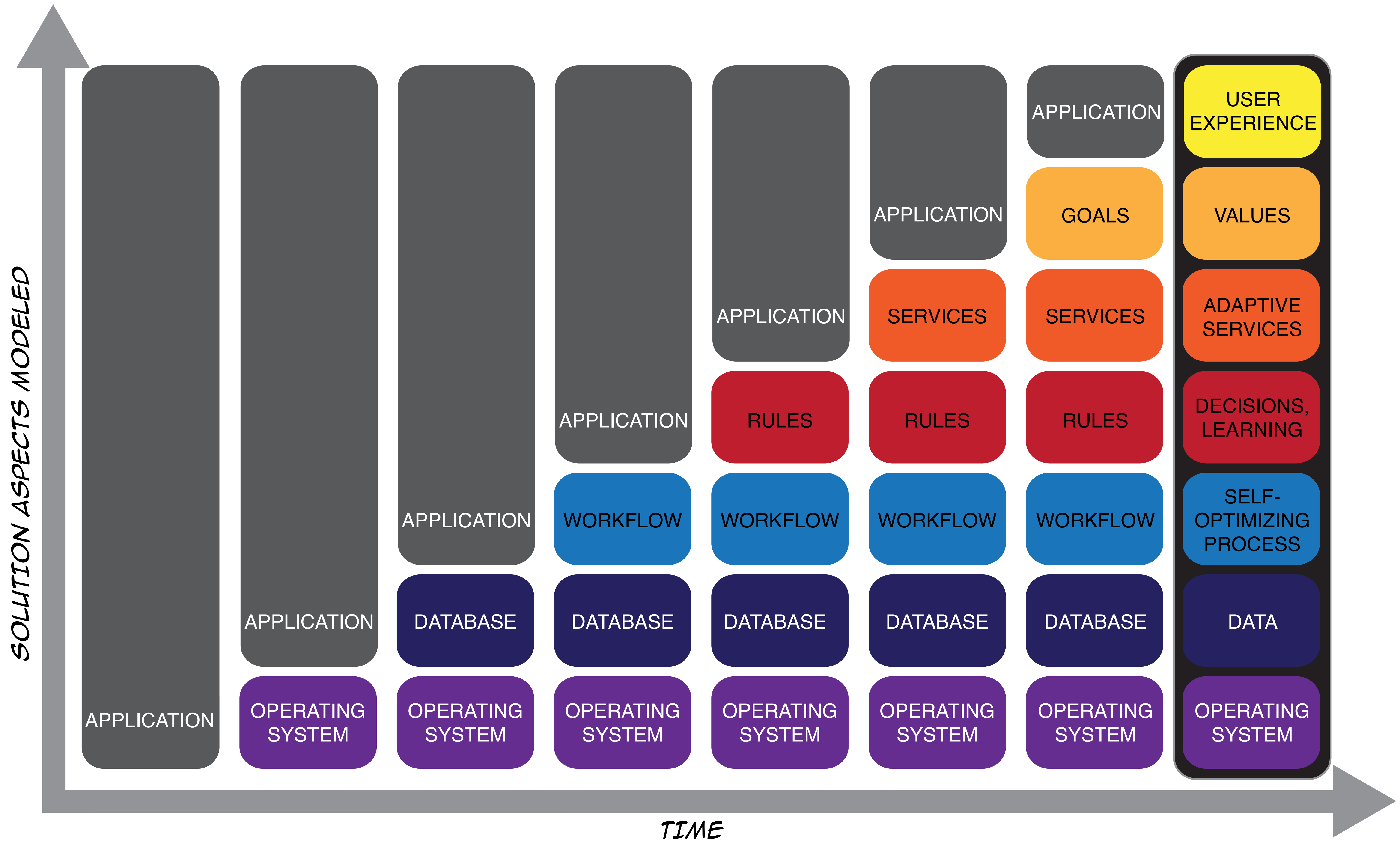
What makes concept computing so different?

It’s a new paradigm that uses semantic models to drive every aspect of the computing solution. This includes processes, data, decision-making, system interfaces, and user experience.

Also, these direct-execution models power every stage of the solution life cycle—from initial development to operations, to ongoing changes and evolution of new capabilities.

How are concept computing models different?

They're declarative and constraint-based. Plus, they're not separate.



Concept computing modeling is different. It provides a unified environment for creating, managing, and executing all types of models. Every aspect of the solution is model-driven, context-aware, and semantic.

How is this different?
Historically, lots of things have been modeled.
But, modeling only seemed cost-effective for individual aspects of software applications.

Going back to the beginning of IT, there was only an application program. It was a deck of cards that gave instructions to a computer. It was low-level code.
Over the decades, we began model knowledge about some things separately and take this functionality out of the application, so that multiple programs could share it.

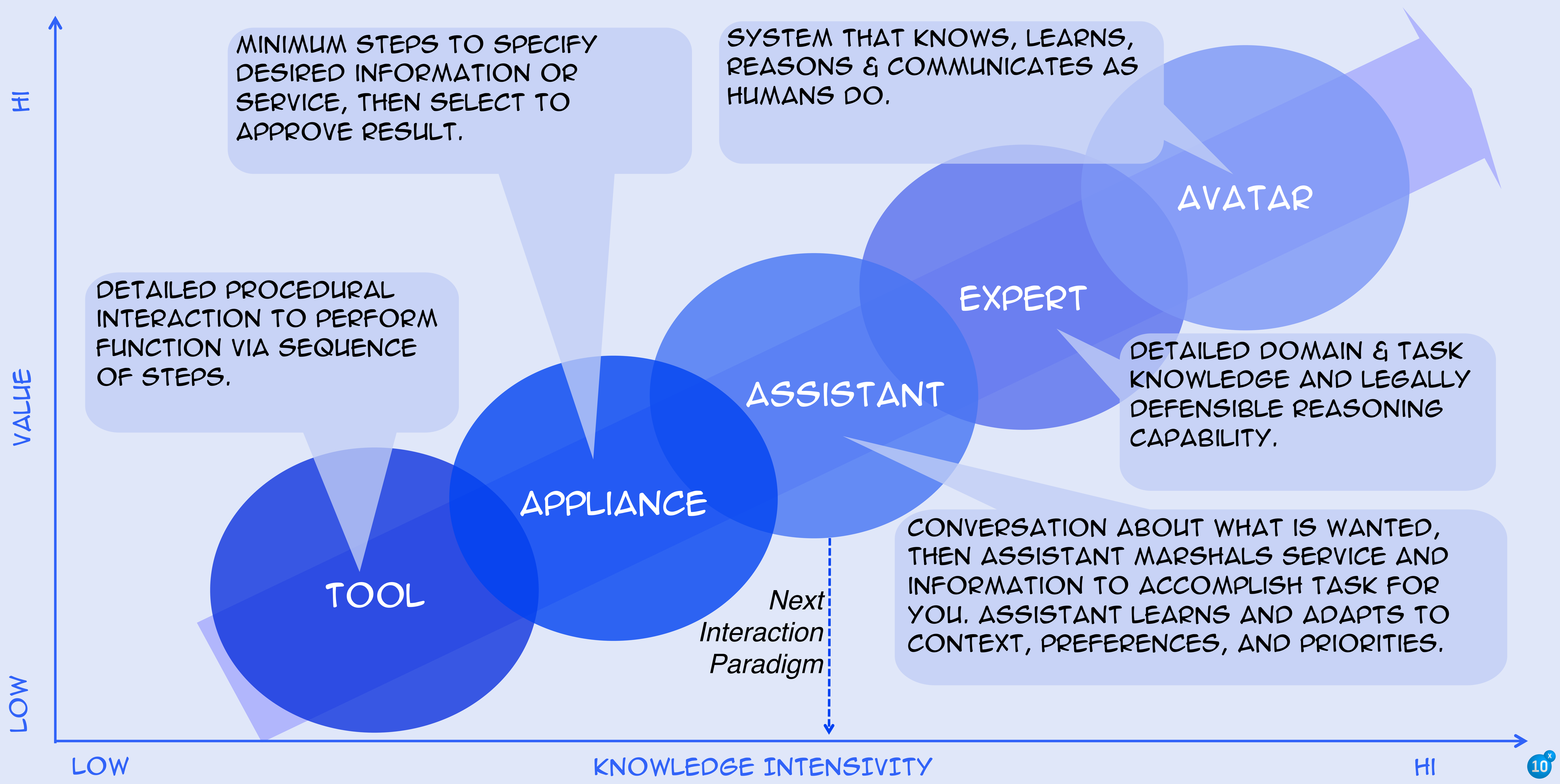
The sequence was something like this: operating systems, then data, workflow, rules, services, and goals.

As modeling evolved, different kinds of concepts required separate tools to model them.
With different kinds of modeling tools came different formalisms and standards.
For example for: data schemas, decisions using business rules, processes flow-charted with BPMN, services accessed through APIs.
Different formalisms and standards result in tools that don't know about each other and don't share semantics.
That's a problem when you want to combine multiple types of models in an application. It gets complicated.
Often you are obliged to write some code. Other times, you import or export models into other tools, which adds a layer of complexity.

With concept computing this extra work goes away. Different types of models all execute in the same environment.
Further, there is now hardware designed for concept computing at scale.

The first aspect of concept computing we highlight is ‘smart user experience.’ Concept computing enables making user experience simpler, smarter and more helpful. Make my digital life easier, more useful, and more fun.

Smart User Experience

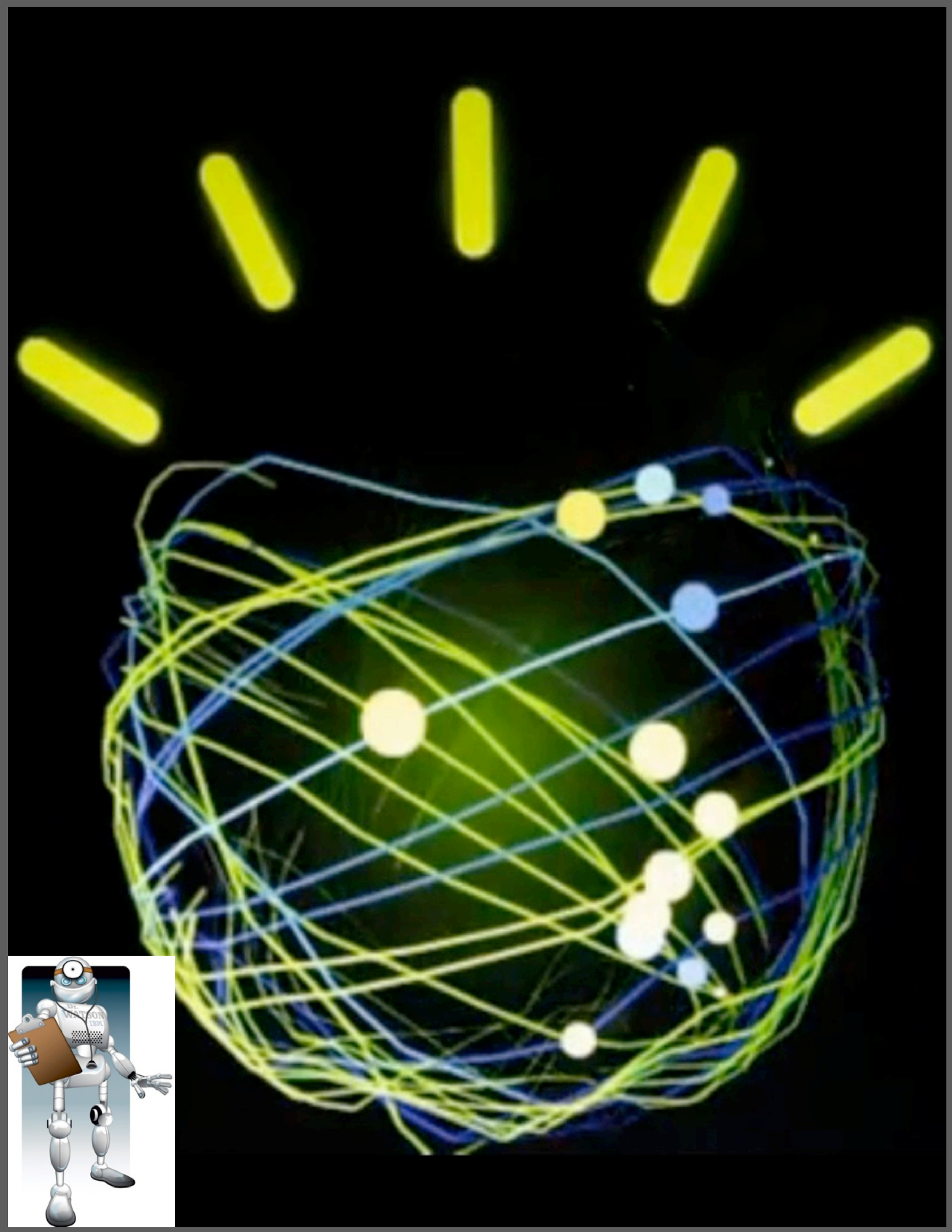


Semantic and model-driven user interface design allows implementation of different types of “smarter” user experience.

The progression from lower left to upper right is from fixed tools, to appliances, to advisors, to virtual assistants that can complete tasks, to expert agents.

Increasing knowledge intensivity of the user interface correlates with increase in value.

Stephen Wolfram



IBM's Watson

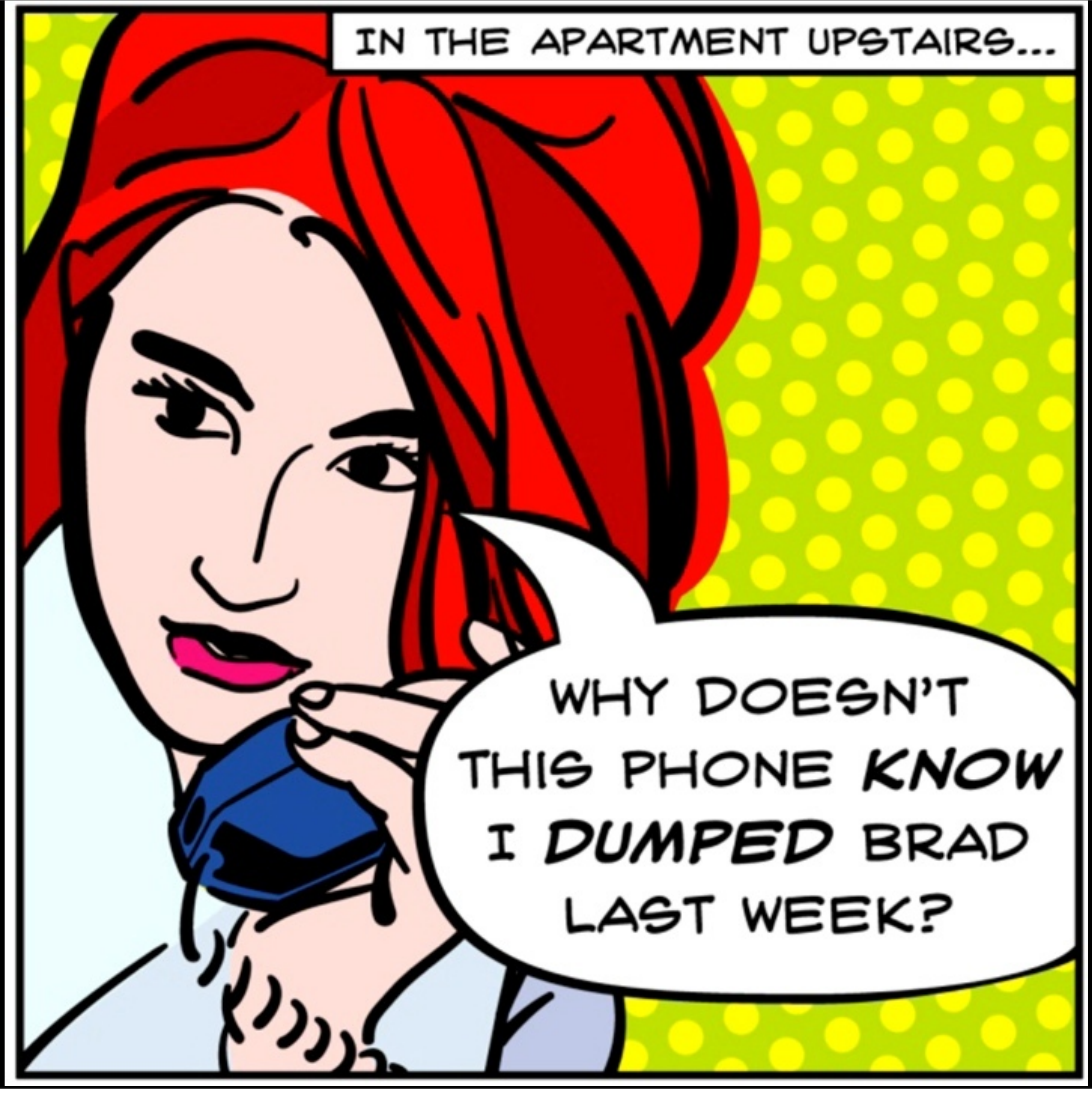
Tom Gruber

Smarter user interfaces are already coming to the mainstream consumer internet.
Wolfram's Alpha, IBM's Watson, and Apple's SIRI are three examples, and much more is on the way.

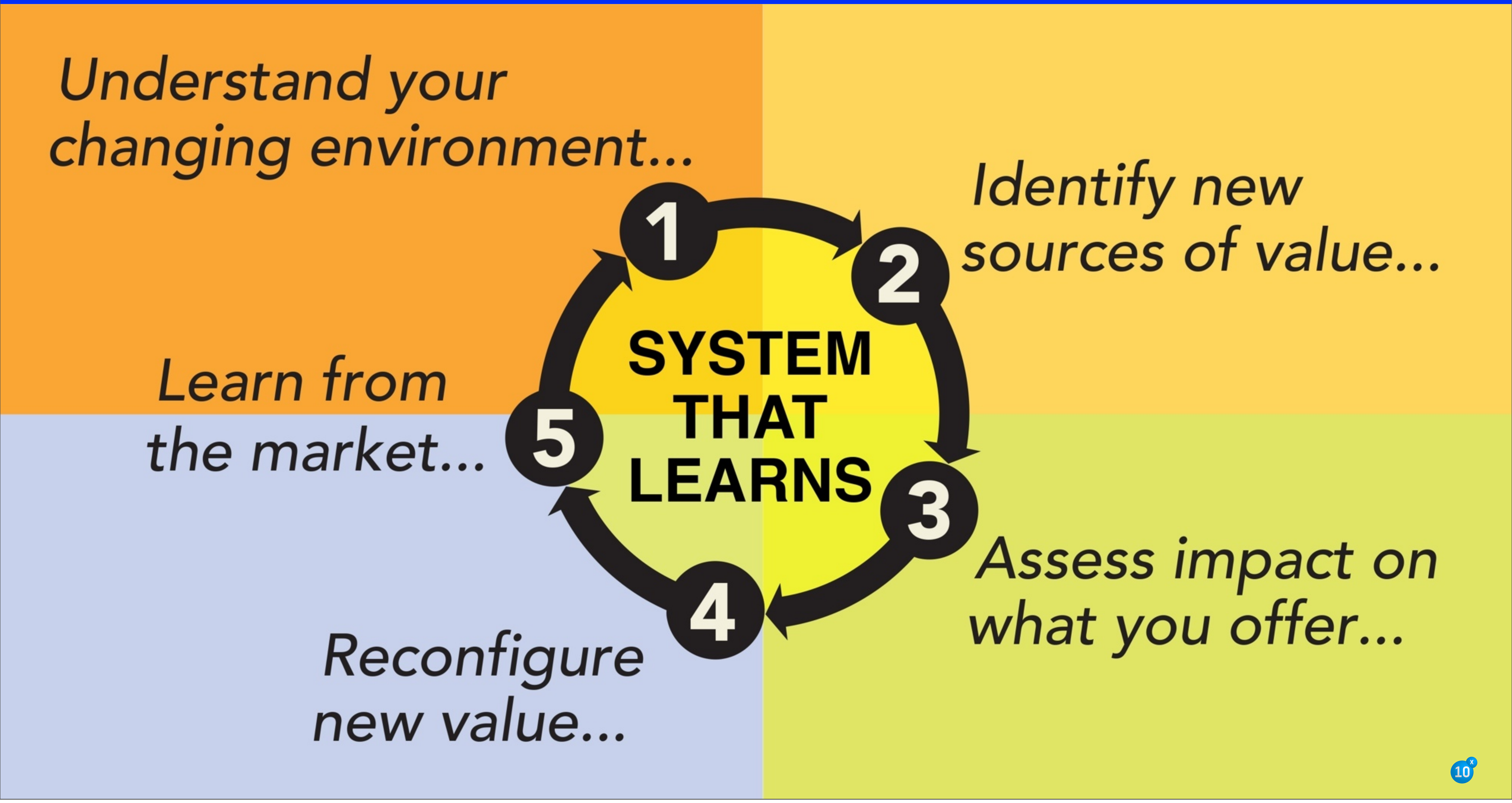
Wolfram's Alpha brings the world of well curated, computable scientific knowledge to the individual via the web.

IBM's Watson began as a grand challenge to answer questions on Jeopardy. Now Watson is learning medicine and how to act as a helpful advisor to physicians.

Tom Gruber served as CTO for the development of Apple's SIRI, that understands what you tell it and can marshal services to help complete tasks for you.



Consumer expectations will change rapidly. When mobile user interfaces compute with knowledge, the system can answer questions, anticipate needs, give advice, and complete tasks. We'll become angry when that device doesn't understand concepts.



Something else that is coming to the user experience is systems that learn and get better with use and with scale. How? One way is that users teach the system something new, or curate what it already knows. Another way is the machine learns by observing behaviors, mining and analyzing data, or sharing machine interpretable knowledge.

This diagram depicts the cycle of learning as it might apply to an individual, an organization, or a product in perpetual beta. In a hyper-networked world, business processes capture and process feed back from sensors, users, and other systems in order to learn and improve performance.

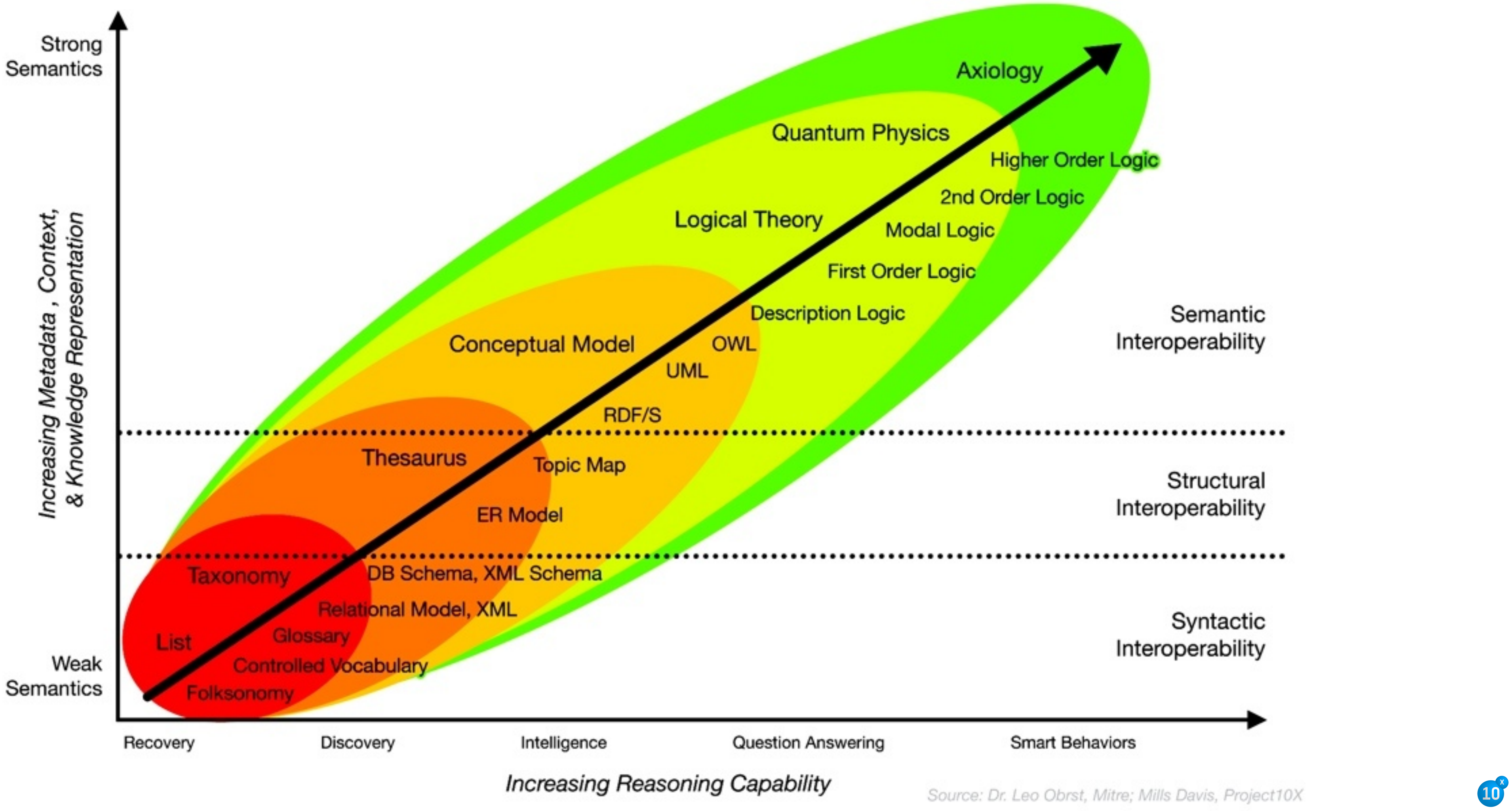
The second aspect of concept computing to discuss is semantic data.

If you want to connect and integrate information, the first thing you have to do is integrate what you know about it.

Semantic web standards are gaining traction as a way of describing different data sources, structures and metadata so that they can be linked together.

Concept computing goes further to put linked data and metadata to work.

Search to Knowing — Spectrum of Knowledge Representation & Reasoning



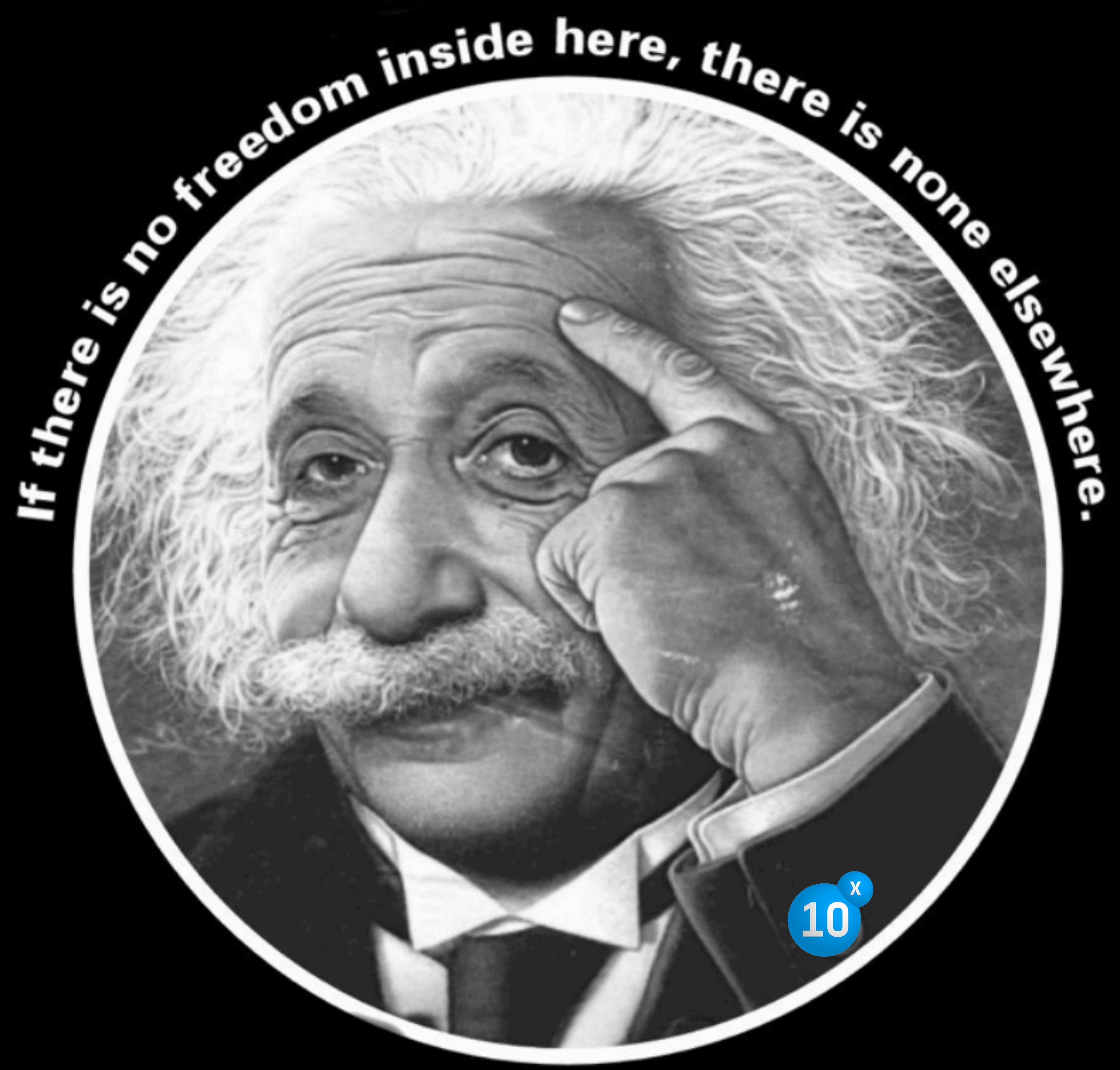
Concept computing spans a comprehensive and expressive spectrum of knowledge representation (KR). Not all knowledge representation is the same. More expressive KR powers greater reasoning capability.

This figure shows a spectrum of executable knowledge representation and reasoning capabilities. As the rigor and expressive power of the semantics and knowledge representation increases, so does the value of the reasoning capacity it enables. From bottom-to-top, the amount, kinds, and complexity, and expressive power knowledge representation increases.

From left-to-right, reasoning capabilities advance from: (a) Information recovery based on linguistic and statistical methods, to (b) Discovery of unexpected relevant information and associations through mining, to (c) Intelligence based on correlation of data sources, connecting the dots, and putting information into context, to (d) Question answering ranging from simple factoids to complex decision-support, to (e) Smart behaviors including robust adaptive and autonomous action.

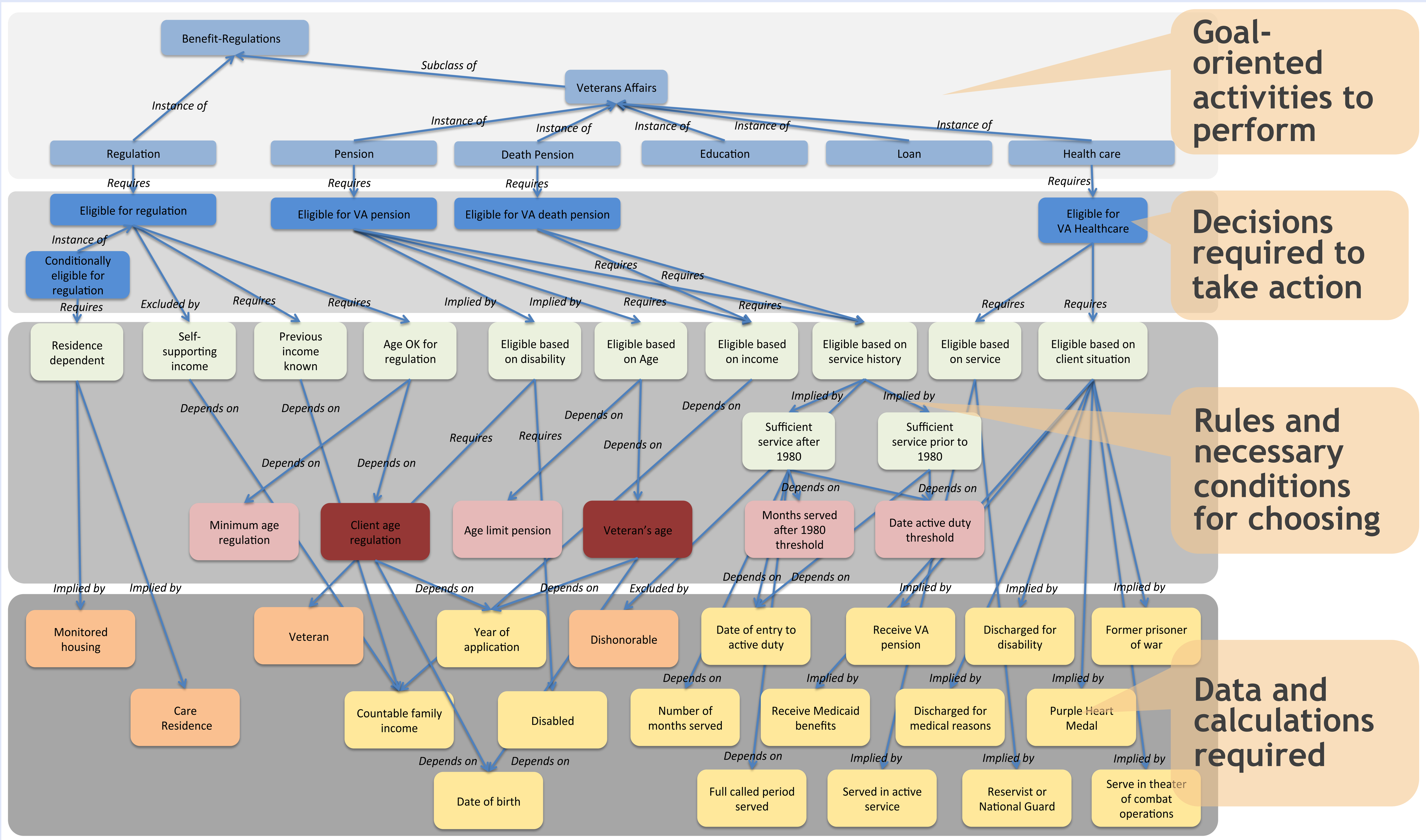
Moving from lower left to upper right, the diagram depicts a spectrum of progressively more capable forms of knowledge representation together with standards and formalisms used to express metadata, associations, models, contexts, and modes of reasoning. More expressive forms of metadata and semantic modeling encompass the simpler forms, and extend their capabilities. In the following topics, we discuss different forms of knowledge representation, then the types of reasoning capabilities they enable.

INTELLIGENT DECISIONS



The next aspect of concept computing we highlight is “intelligent decisions.”

Systems that Know = Policies + Models + Executable Knowledge + Intelligent Decisions



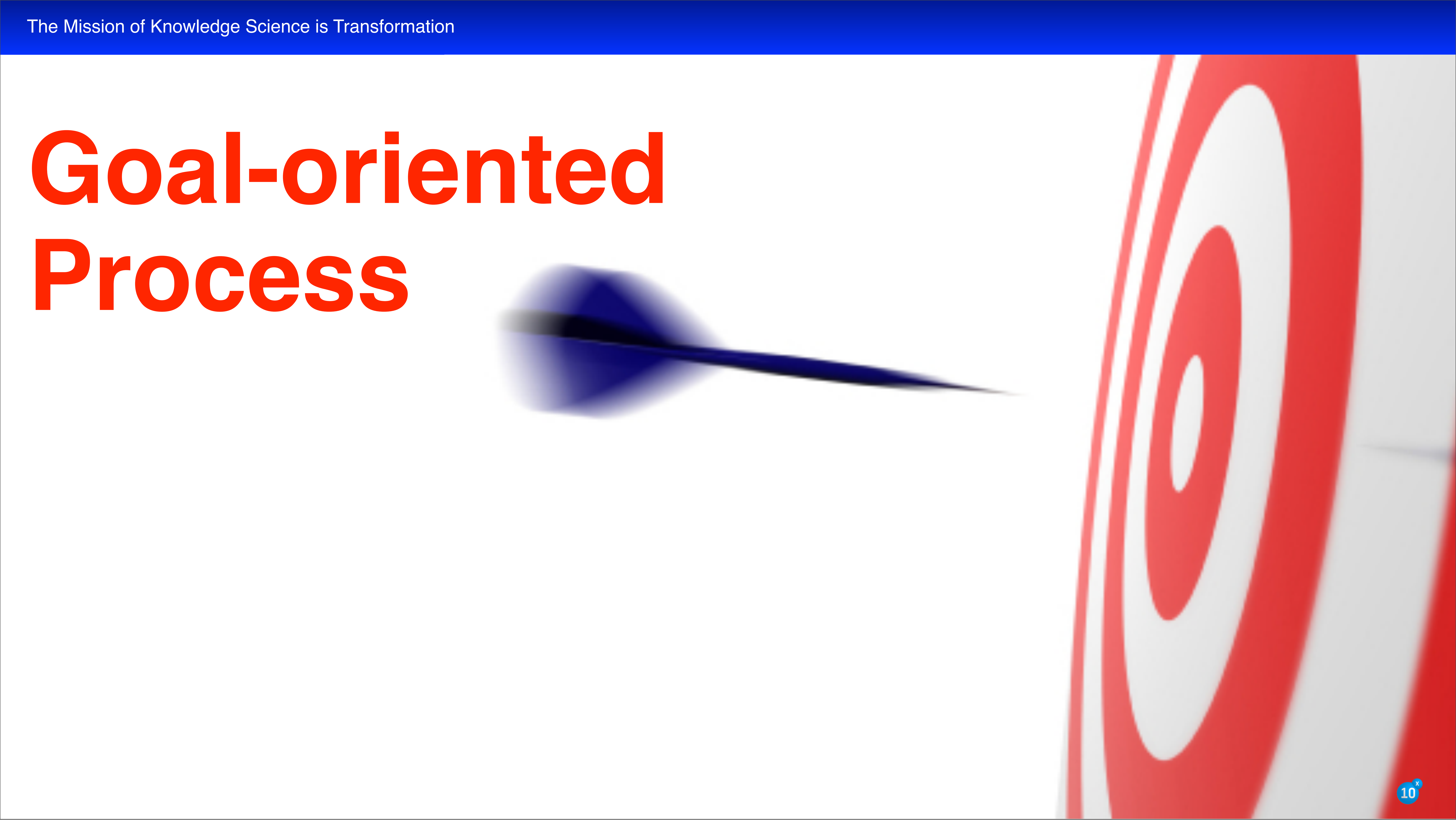
Systems that make intelligent decisions are systems that know. This slide illustrates how systems that know make intelligent decisions.

Across the top: A system that knows captures authoritative sources as models. The theory or business rules in policies, regulations, standards, best practices, etc. combine with factual information to form executable knowledge. An inference engine reasons over the knowledgebase to make decisions.

The diagram depicts a knowledge model used to decide eligibility for multiple benefit programs. Each box is a concept. The lines connecting boxes depict relationships. Different types of relationships express constraints (or business rules) to be satisfied to arrive at a decision.

From top to bottom it shows:

- Goal oriented actions to perform for various benefit programs.
- Decisions required to take action.
- Rules and necessary conditions for choosing
- Data and calculations require to satisfy those conditions



The next aspect of concept computing we highlight is “goal-oriented process.”

Concept computing impacts a spectrum of process types.

1. Fixed transaction processes follow a preset procedural sequence. Straight-through-processes are like this. So are simple workflows and instruction sequences. Trend is to use concept computing (semantic model driven) approaches when transaction systems need to be connected across boundaries.

2. Dynamic case management systems process events and rules in order to determine the specific sequence of steps to follow to reach a goal in this particular case. Modeling the potential variations can be complicate (for example, like a phone tree), or relatively elegant (like a GPS system) depending on how the process gets modeled. Trend is to use goal oriented, event driven concept computing approaches for administrative, investigative, and customer facing processes that are complex and knowledge intensive. Processes are compact and elegant. They adapt and self-optimize when events happen, exceptions occur, and needs change.

3. Emergent projects have an underlying goal-oriented methodology (process model). However, they address problems for which all conditions cannot be pre-defined. Events can occur, which demand definition of a new task, methodology and deliverable outcome. The emergent process model evolves (learns) as well as adapts and self-optimizes.

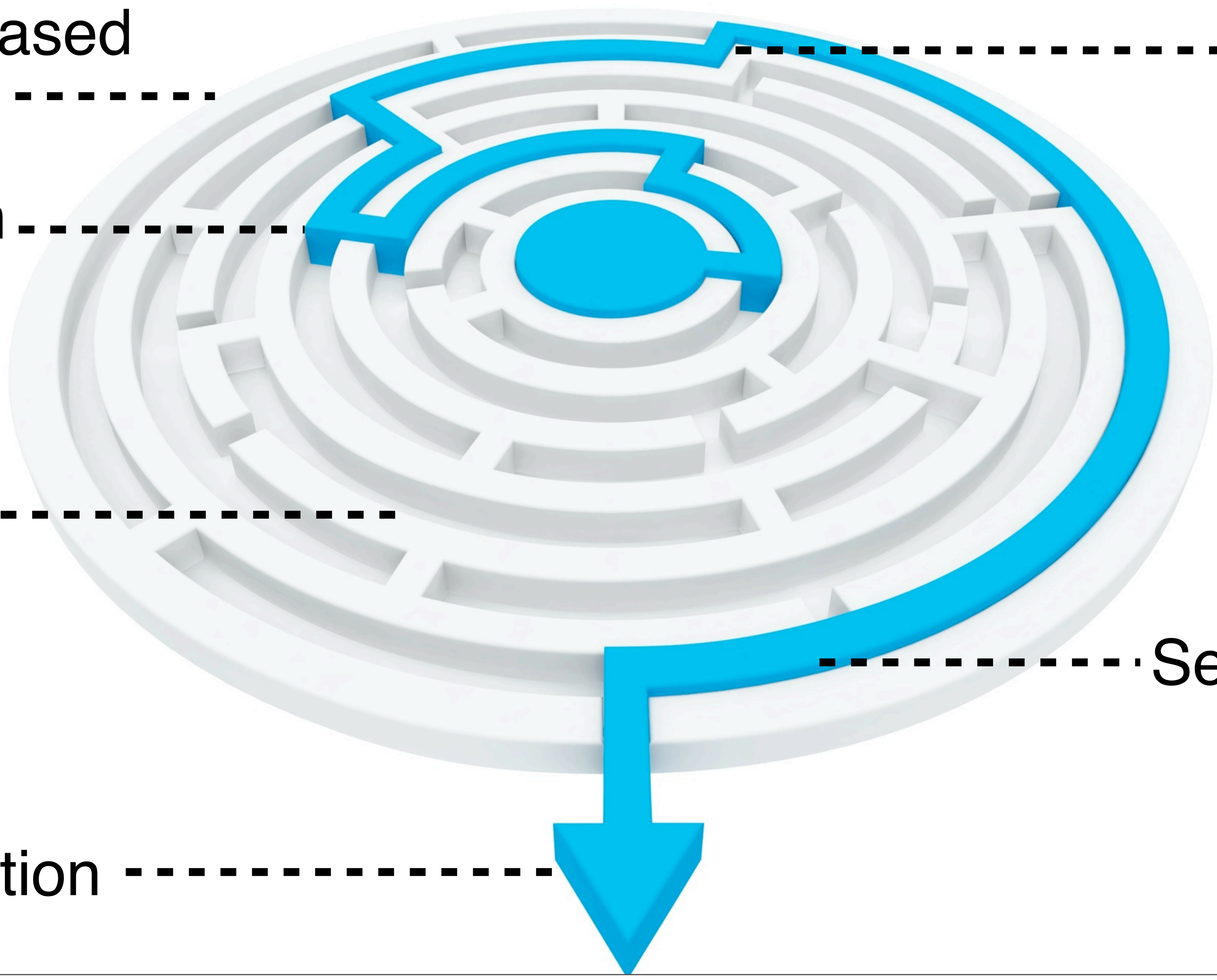
What makes concept computing processes different?

Constraint-based models

Event-driven inferencing

Context awareness

Goal-orientation



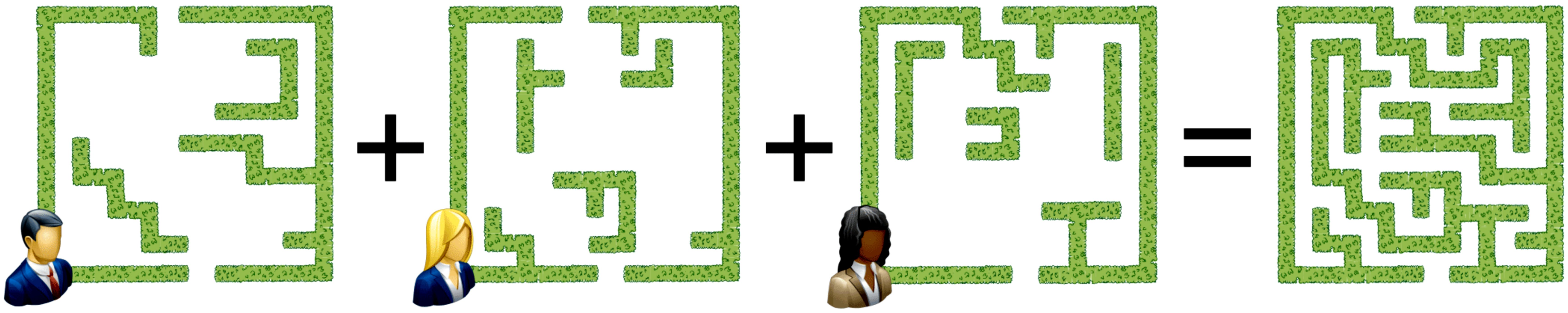
Adaptivity

Self-optimization

This slide highlights six ways that concept computing processes differ from conventional approaches.

Do constraint-based processes scale?

Yes. It is relatively easy to add, combine and manage new constraints. The computer uses the constraints to compute the best process flow.



Laws	Stakeholders	Business rules
Regulations	Organization	Business functions
Policies	Roles	Formula
Standards	Responsibilities	Models of pre- & post-conditions
Best practices	Relationships	

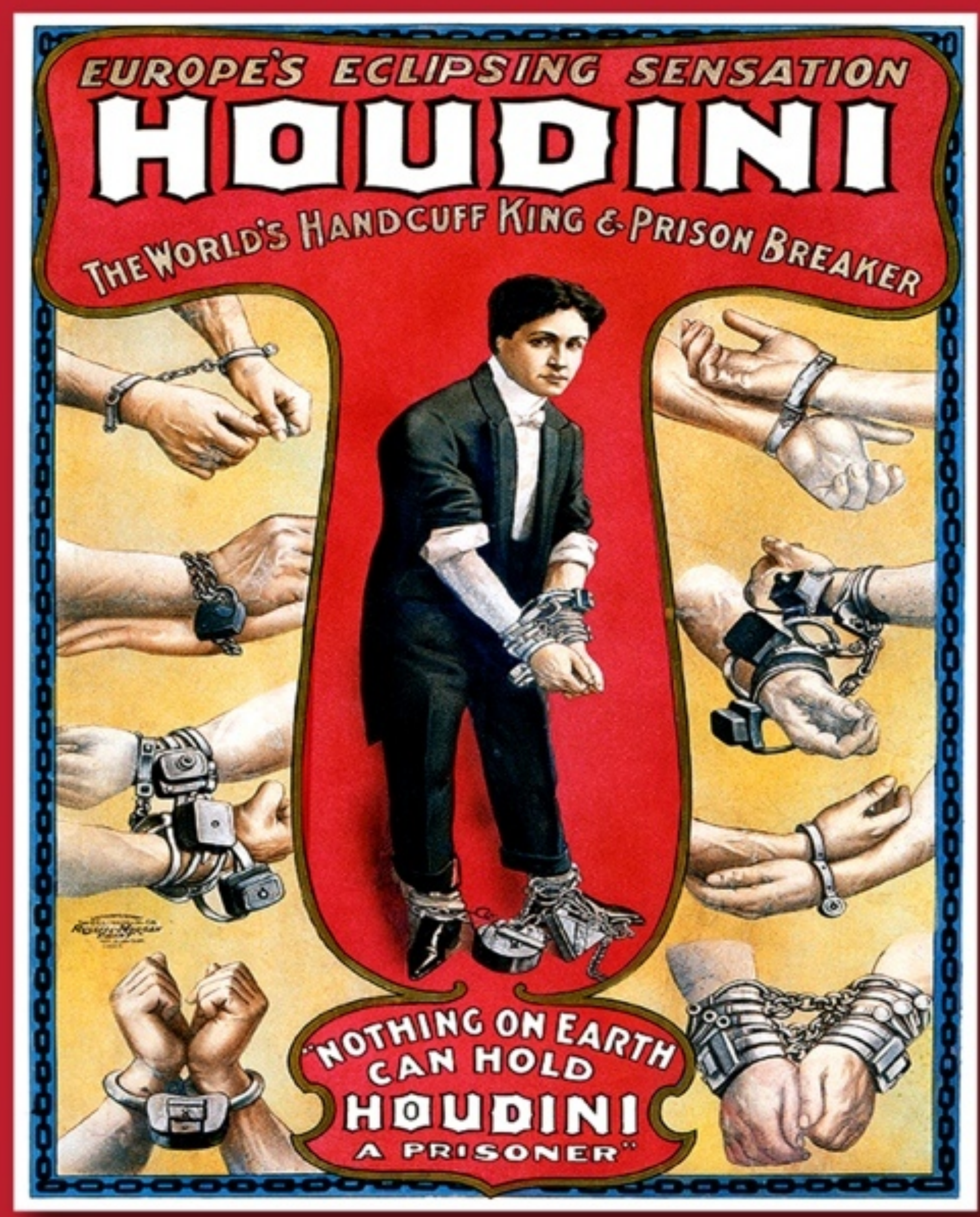
With concept computing, you model constraints rather than procedural flows. The computer figures out the next best action, or most efficient route based on context, events, and goals to be achieved.

Constraint-based processes are scaleable and provide economical ways to solve problems that are pretty intractable with conventional approaches.

CAN YOU ESCAPE YOUR LEGACY SYSTEMS?

BUSINESS IS COMPLEX,
BUT IT CAN BE A LOT LESS
COMPLICATED!

KNOWLEDGE MODELS
INTEGRATE SYSTEMS, DATA &
PROCESSES NON-INVASIVELY.



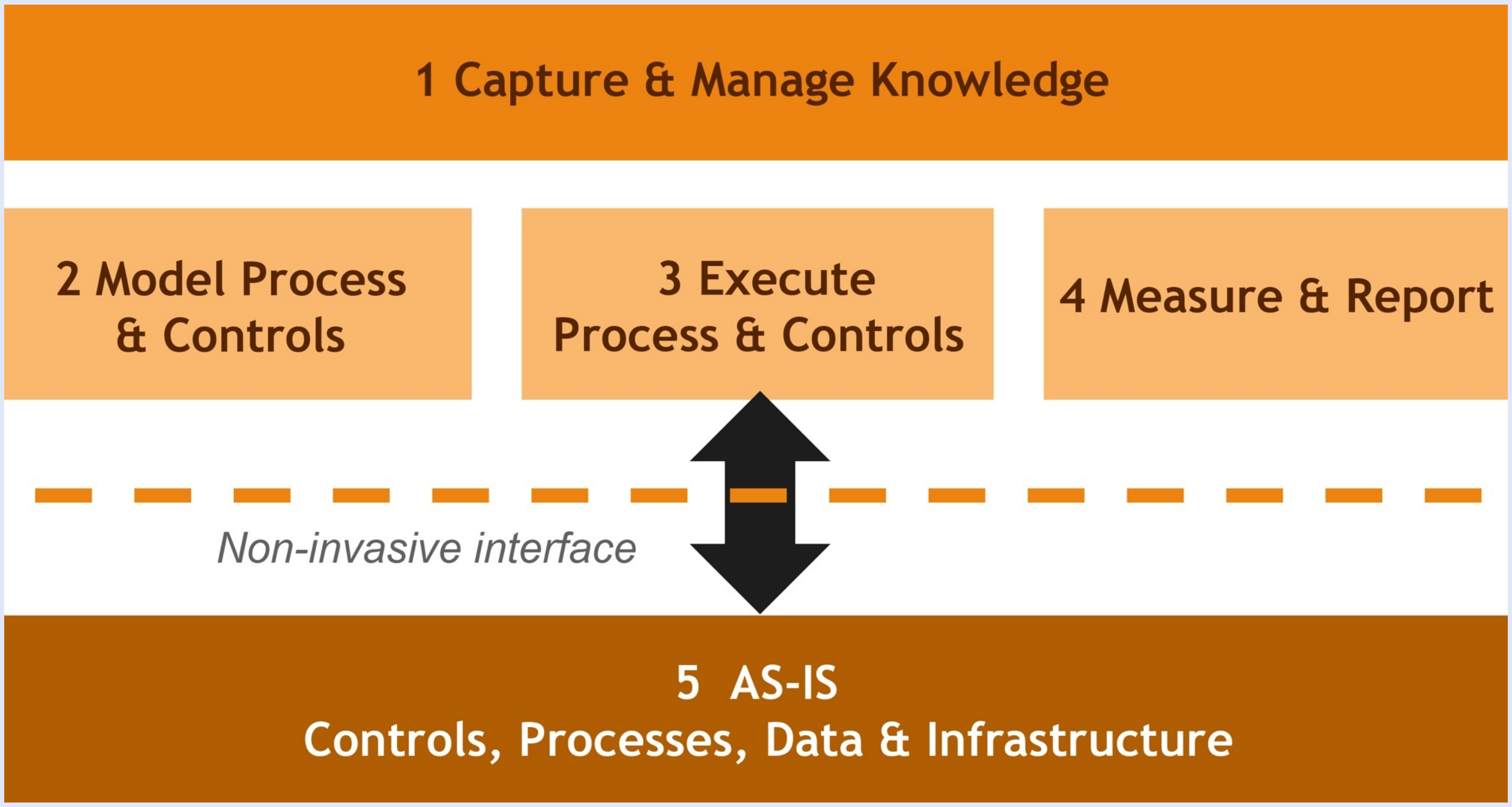
ABOVE THE LINE ARCHITECTURE
ENABLES BUSINESSES TO
STANDARDIZE AT A HIGHER LEVEL.
TRANSFORM INCREMENTALLY &
INTERCEPT THE FUTURE.

WITH CONCEPT COMPUTING YOU CAN!

Concept computing is technology designed to enable businesses to modernize systems, innovate, and transform to implement their strategy.

What is above the line architecture?

It's how concept computing separates the "know" from legacy systems.



Concept computing implements a different kind of architecture, which we call "above the line" architecture.

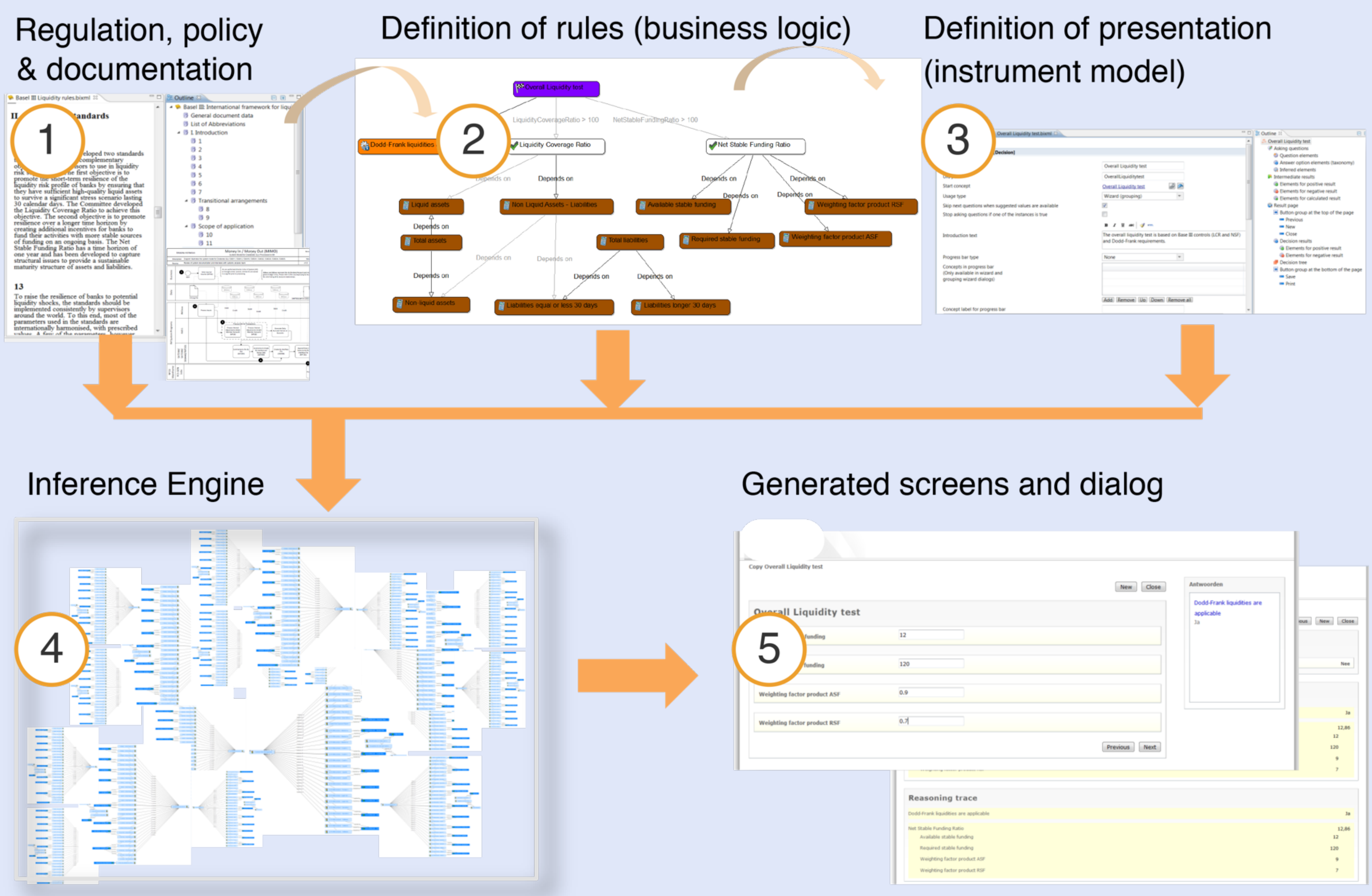
First, it captures manages authoritative sources of knowledge as models. For example the theory or business rules in policies, regulations, standards, best practices, etc. What is different is that this knowledge is computer executable as well as understandable by people.

Second, this knowledge is used to model processes and controls that establish the operational system.

Third, in execution knowledge models combine with factual information. An inference engine reasons over the knowledgebase to make decisions and take actions.

Fourth the system journals everything -- definitions, data, behaviors, etc. -- enabling a spectrum of measurement, and reporting. For example, the system self documents -- a document is just another way of expressing the underlying knowledge model. The system can explain its decisions and actions -- the inference engine can play back how it interpreted business logic and data to drive system behaviors.

How does direct model execution work?



This slide illustrates how direct model execution works.

Across the top: Authoritative knowledge gets captured and converted to knowledge models that express the goals, business logic, and behaviors of the system. Business logic constrains the behavior of instruments used to present information to and from people and machines.

Across the bottom: An inference engine interprets the models and directs the generation of screens, dialogs and other behaviors of the system.

When is a maze not a maze?

When you have a “process GPS” to tell you the best route.

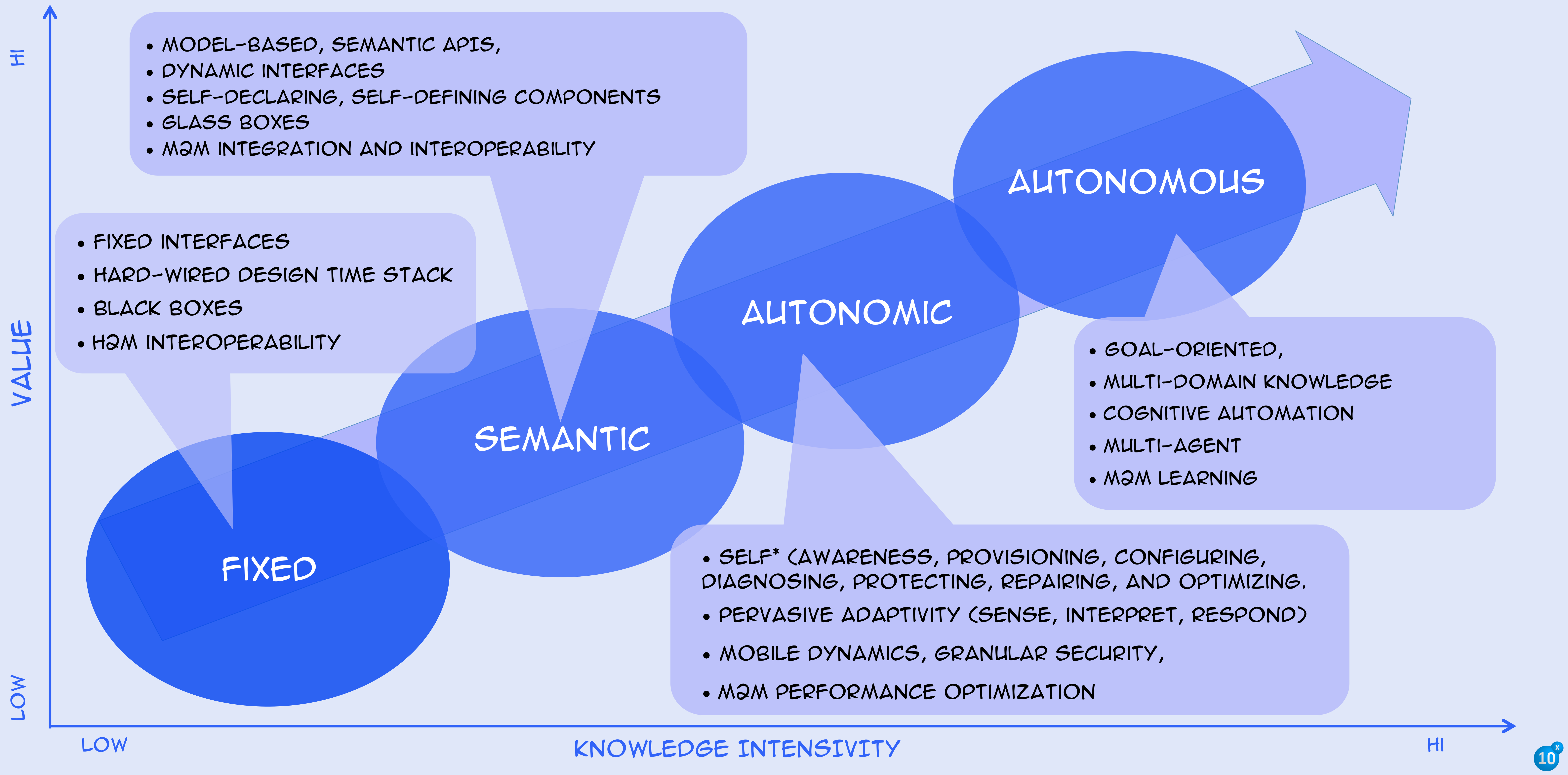
Concept computing processes are like a “GPS” for processes that is always seeking the best way to reach the goal.

What it is not is a “phone tree”

The result is that concept computing processes give you the smartest, fastest workflow -- one that travels the fewest steps, touches the fewest hands, and does as much as possible for you.

The fifth aspect of concept computing we highlight is “autonomic infrastructure.”

Autonomic Infrastructure

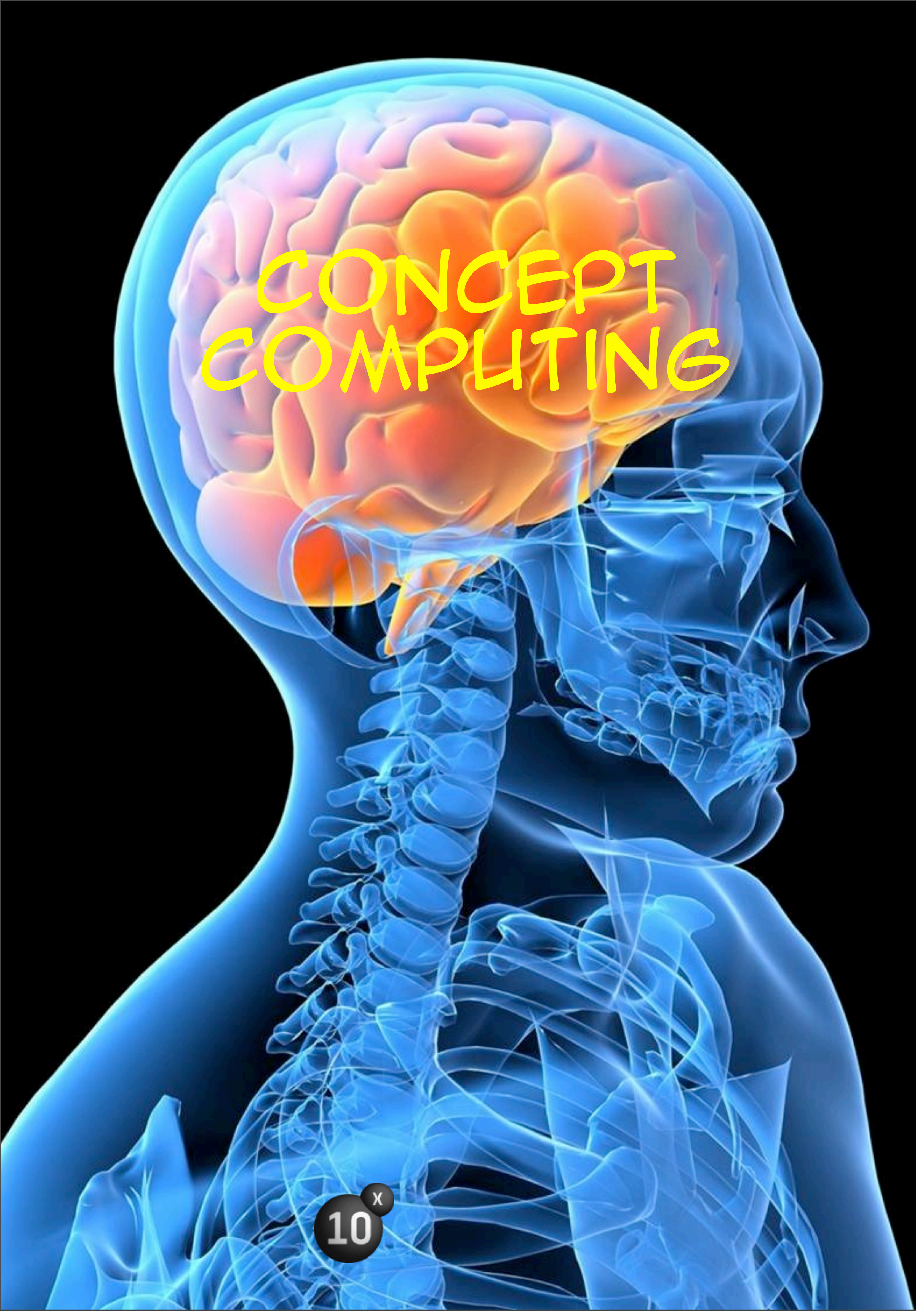


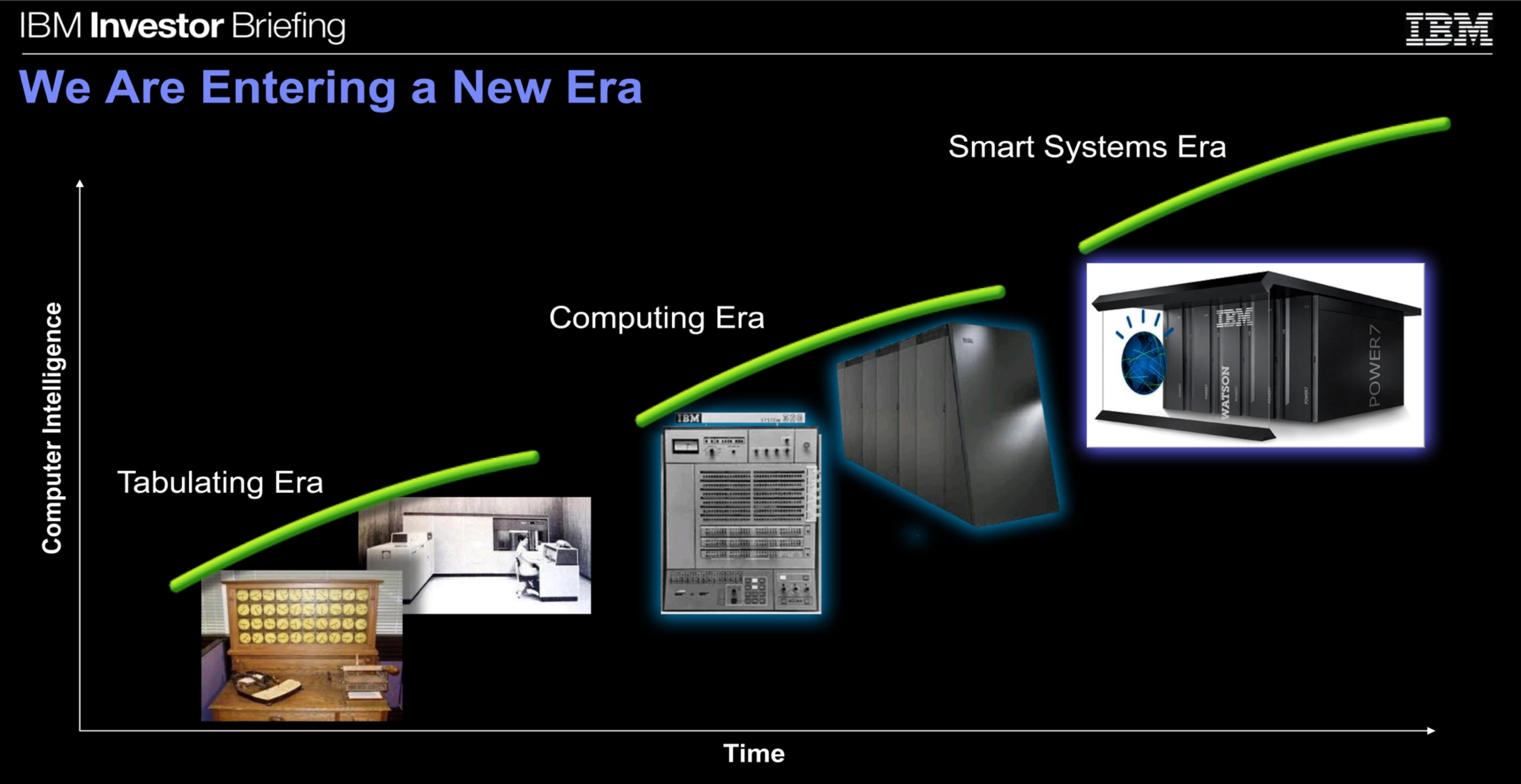
This diagram shows the direction where infrastructure is headed. Infrastructure gets smarter. The trend depicted here is from fixed to semantic to autonomic, to autonomous components, systems, and ecosystems.

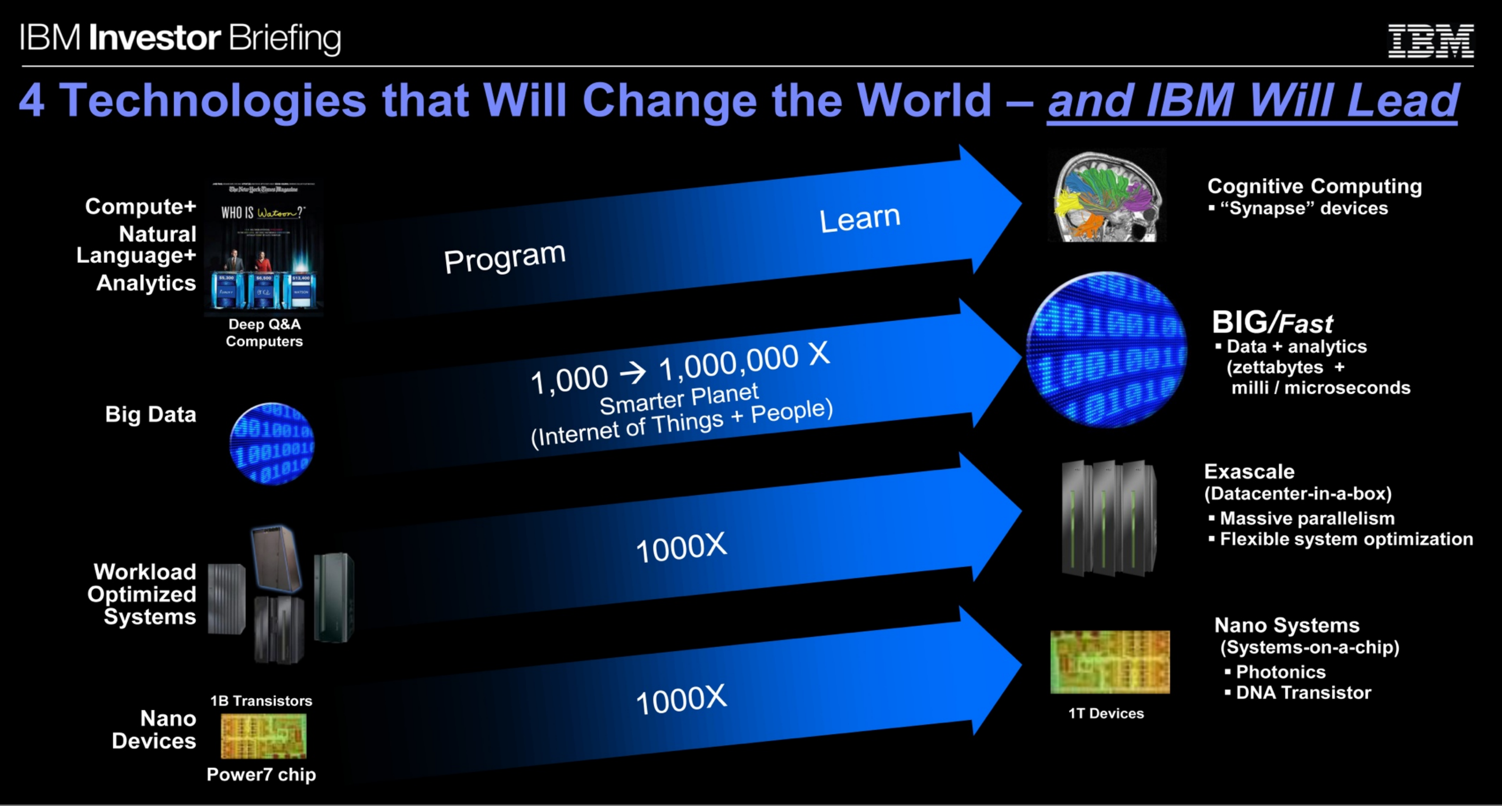
Concept computing technologies can solve problems of scale, complexity, function, security, performance & agility. IT has reached the limits of what it can do with stacks, object orientation, metadata madness, fixed knowledge embedded in code (with no run-time learning), and architected development versus emergent solutions.

Concept computing can overcome problems of integration, interoperability, parallelism, mobility, ubiquity/pervasiveness, scale, complexity, speed, power, cost, performance, autonomics, automation, intelligence, identity, security, and ease of programming.

Now take a deep breath :-)



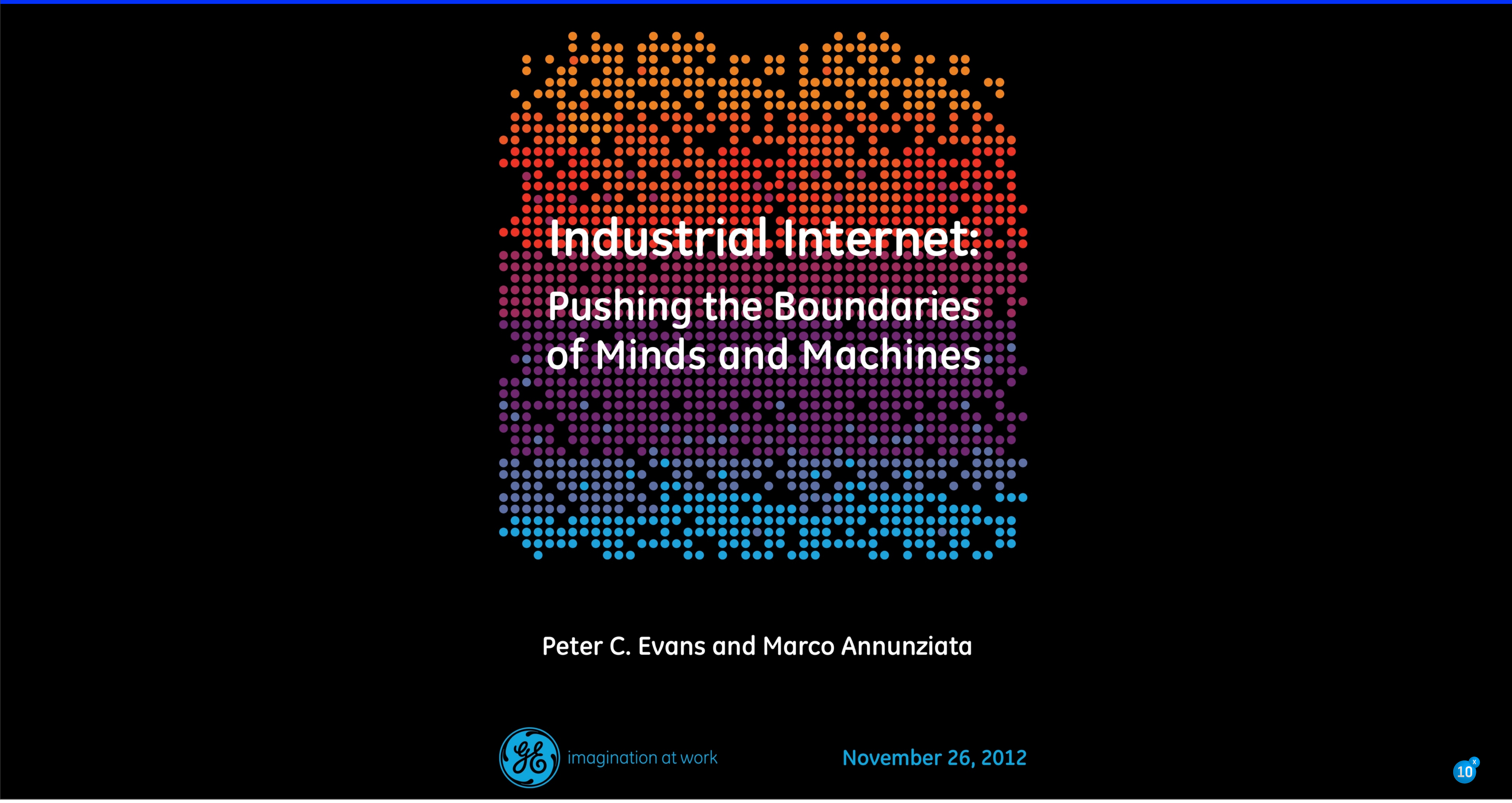




Concept computing demands big think.

What is different is that memory and compute power is becoming a non-issue. Super computing will be everywhere. Supercomputing at the edge. In smart devices. In the cloud. Intel, Nvidia, Cray, IBM, and more. Semiconductor companies have supercomputing roadmaps and market plans.

Speaking of technology drivers for concept computing. Look at the two diagrams from IBM to the right. The first says we started with tabulating machines and we are now entering the era of smart systems. The second diagram identifies four technologies that will have a 1000X impact on capability and performance. The top one is cognitive computing.

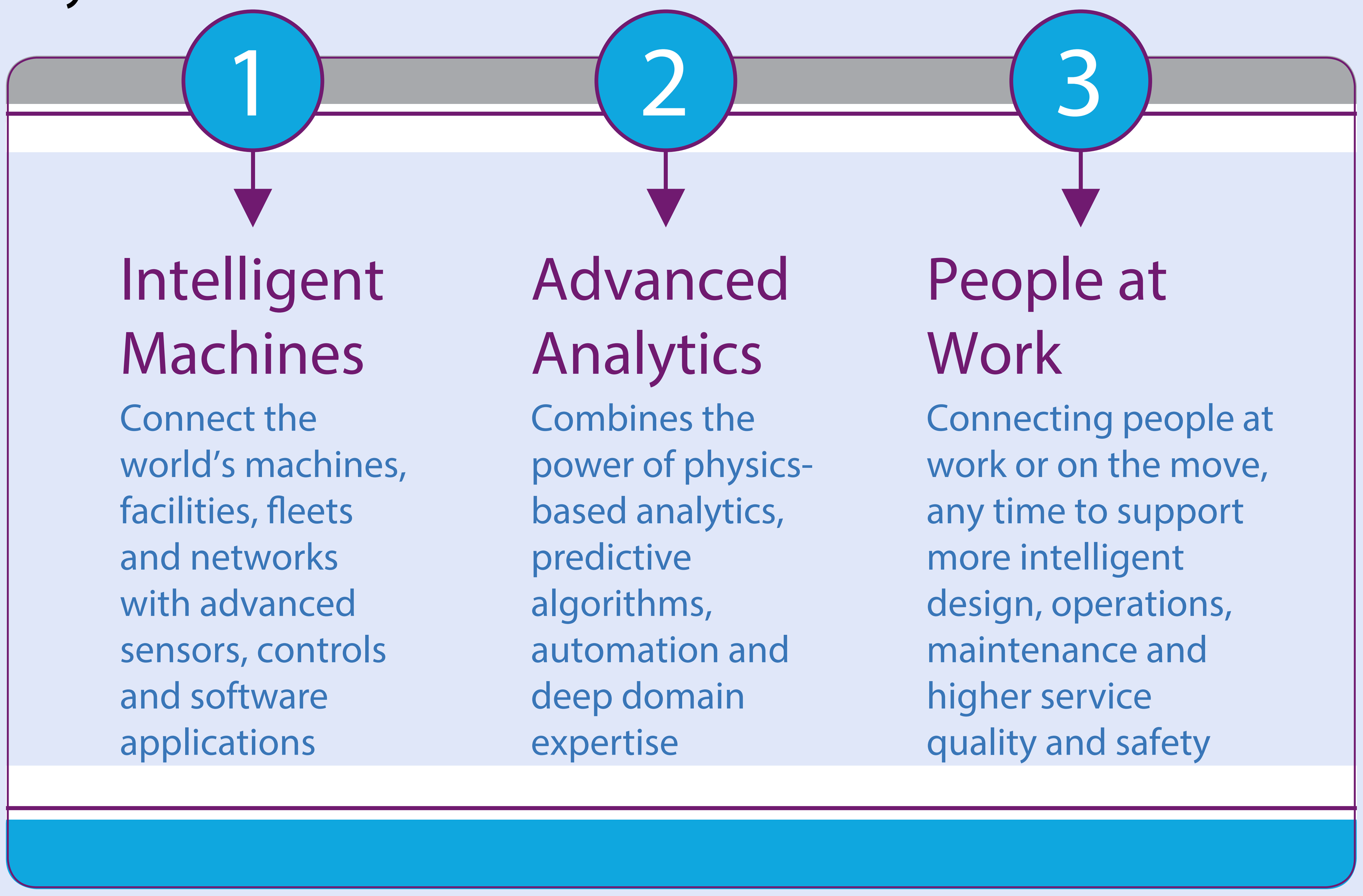


Big companies are beginning to place big bets on smart technologies and concept computing.

For example, last fall, General Electric came out with a study predicting huge economic growth resulting from the Industrial Internet. The two authors are GE's top strategist and chief economist. It's a serious report.

Here is the thesis. Mechanization of work over the past 200 years has resulted in a 50X worker productivity increase. The next stage is the integration of machines with computing and the Internet. The result, they predict will be tens of trillions of dollars in economic expansion and improved quality of life worldwide.

Key Elements of the Industrial Internet



Value of the Industrial Internet: The Power of 1 Percent

What if... Potential Performance Gains in Key Sectors

Industry	Segment	Type of Savings	Estimated Value Over 15 Years (Billion nominal US dollars)
Aviation	Commercial	1% Fuel Savings	$30B
Power	Gas-fired Generation	1% Fuel Savings	$66B
Healthcare	System-wide	1% Reduction in System Inefficiency	$63B
Rail	Freight	1% Reduction in System Inefficiency	$27B
Oil & Gas	Exploration & Development	1% Reduction in Capital Expenditures	$90B

Note: Illustrative examples based on potential one percent savings applied across specific global industry sectors.
Source: GE estimates

Here are two slides from the GE report.

The one on the left identifies three key elements of the industrial internet. The implication is that patterns of work will change and that industrial products and processes will gain a cradle to sunset life history.

The diagram to the right projects the value of the industrial internet in the form of potential performance gains across five economic sectors. This is a minimal projection, but we're still talking $ billions.

GE’s already taking the industrial internet thesis to the street.

Their recent TV commercials bring back Agent Smith from the Matrix. This scene is about the interconnection and intelligent interaction of machines, software, and healthcare professionals to deliver improved outcomes for patients -- a waiting room becomes, just a room.

One version of the ad ends with agent Smith offering a child a choice of lollypops -- a red one or a blue one.

Why cities? Applying knowledge science and concept computing to transform our cities is a mission worthy of the journey.

In 2008, the number of people living in urban areas worldwide rose above 50% for the first time, and will rise to 70% by 2050, according to the United Nations. The world's urban population will reach 5 billion by 2030. Using only 2% of the entire planet's land mass, cities today are using 75% of the world's natural resources and account for 80% of the planet's greenhouse gas emissions. Worldwide, 476 cities have more than one million people living in them today. But by 2030, China alone will have 221 such cities, while the U.S. will still have just nine cities with a one million-plus population.

Cities are a primary driver of economic growth, innovation and opportunity. They are powerful magnets for highly skilled and educated workers and gateways for new immigrants. They are centers of business, generators and suppliers of financial capital, important trade hubs for both goods and services, and the focal points of global commerce. Cities house substantial infrastructure assets and major institutions that power regional prosperity and the nation's quality of life. Cities are strategic leverage points for strengthening the national economy and competitiveness.

Cities today face significant challenges including increasing populations, aging infrastructures, and declining budgets. Also, cities compete with each other, not only for resources and investments (public and private). They increasingly compete to attract certain type of residents and visitors. Forward-thinking cities are taking action now — focused on staying competitive, maximizing the resources at their disposal, and laying the groundwork for transformation.

What makes a city great?

Becoming a vibrant cultural & economic hub in our connected global economy.

A Safe and Protected City
As city has to be safe before anything else, by both passive and reactive strategies enforcement agencies need to work in a trusted partnership with the community to provide a safe and trusted environment for all

Operational Efficiencies
Be the best stewards of our resources and talents to make our services best in class in terms of efficient operations today and adaptability for needs in the future.

Excellent Customer Service
Provide citizen centric services across all of our departments whether dealing with a single service or as a multi service combination.

Environmental Quality
Ensure that our built and natural spaces are maintained to the highest levels and are enjoyed by the whole community.

Develop our Knowledge Capital
By attracting and developing knowledge workers into our city, through the use of innovative technologies and a culture of lifelong learning we create a virtuous cycle and an accumulation of knowledge capital.

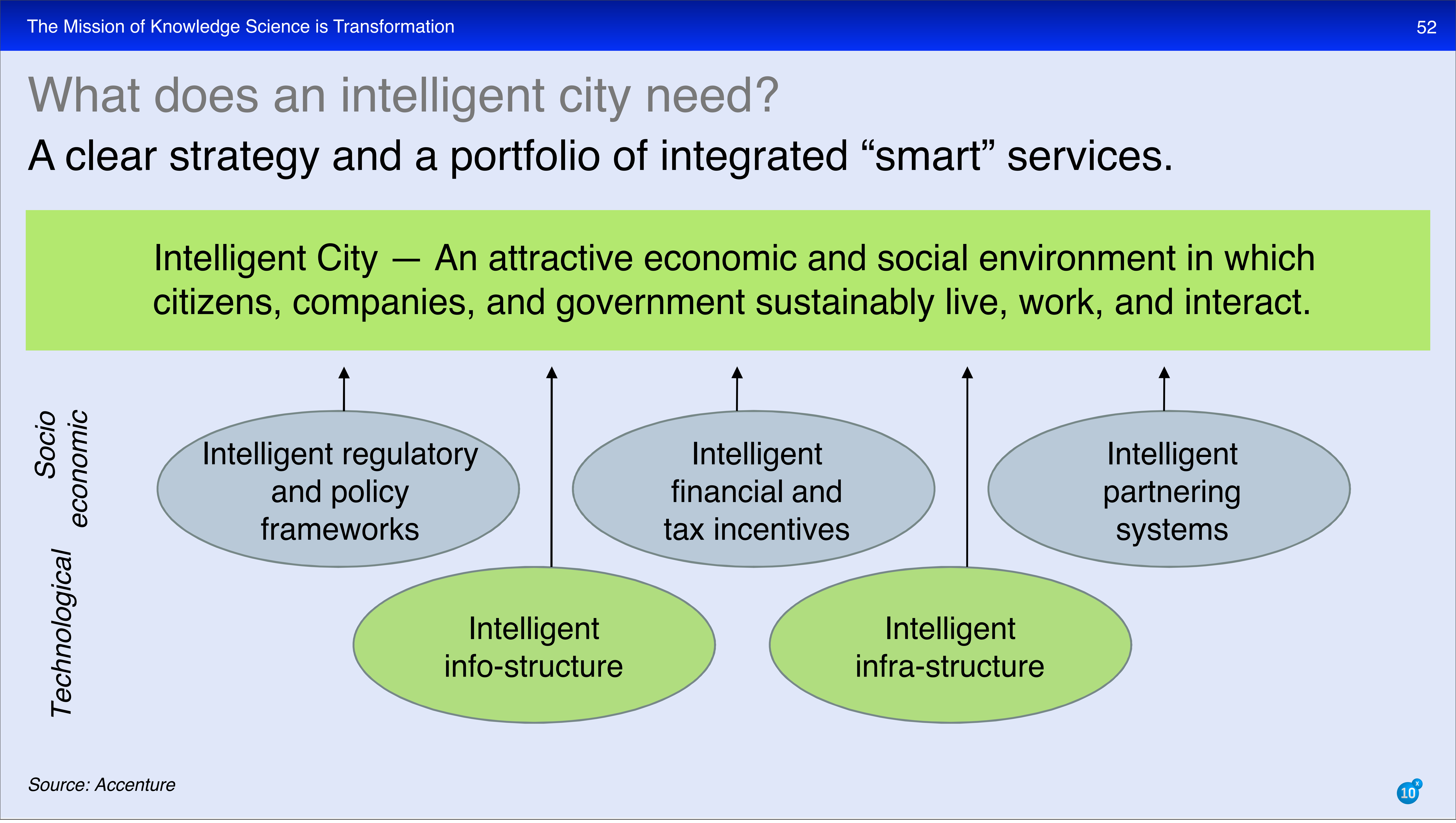
Economic Development
Make our city a great place to create and develop a business. Integrate incentives and services. Provide a place where the fusion of human knowledge, technology capacity, and capital creates sustainable value.

An intelligent city can be defined as a city which systematically makes use of ICT to turn its surplus into resources, promote integrated and multi-functional solutions, and improve its level of mobility and connectedness. It does all this through participatory governance based on collaboration and open source (i.e., shared) knowledge.

Multiple characteristics go into making a city attractive to citizens and businesses, for example:

- Culture and education
- Employment
- Capital
- Geography and climate
- Demographics
- Accessibility
- Sustainable development
- Social policies
- Infrastructure(s)
- Housing
- Urban planning
- Political governance

According to Richard Florida, cities that will come out on top will be those that fare best in terms of the 3Ts—*technology, talent and tolerance.* "For real innovation and sustained economic growth a place must offer all three." Florida adds that "tolerance—or, broadly speaking, openness to diversity—provides an additional source of economic advantage that works alongside technology and talent. The places that are most open to new ideas and that attract talented and creative people from across the globe broaden both their technology and talent capabilities, gaining substantial economic edge."



Cities need to deploy common platforms across multiple service layers to drive economies of scope and scale, and to generate a unified and coherent 'customer experience' for all citizens. This increases the complexity of the urban ecosystem of digital services, driving a greater than ever need for effective partnerships and clear sighted orchestration to align the large number of stakeholders.

What's not smart?

First of all, a city is not smart when there is too much of everything in it. An excess of cars, food, water, energy consumption etc. is the sign of an unsustainable city defined by inefficiency. Instead, the waste streams and the surplus of the city should be used as a valuable input in new production or as a source of energy. The waste of the city must be converted and used in sustainable ways. A Smart City turns its surplus into resources.

Secondly, a city is not smart when the different networks, which define it are not able to communicate and function together in systems. When the power grid, for instance, is not able to communicate with the electrical devices of the city, how can they know when it would be smartest to use electricity? Likewise, when the parking spaces of the city are not equipped with smart parking meters, how can car owners know where to go in order to find a parking space? Such a city has developed separate solutions to common problems. This does not only lead to a duplication of work, but is time consuming and expensive as well. Instead, the solutions of the Smart City must be integrated and multi-functional.

Thirdly, a city is not smart when the systems and networks, which it contains, are static and immobile. Having to wait in long lines of cars during rush hour is not smart. Instead, the mantra should be 'fewer cars and more mobility'. Furthermore, a stagnant city is not just an inefficient city; its lack of flow impedes innovation and creativity among its many stakeholders. A high level of mobility and integration allowing people, information, capital, and energy to flow together easily characterizes the smart city.

What sorts of barriers do intelligent cities need to overcome?

- **Regulatory Barriers:** Utilities business model based on making profits by selling more power. Relevant policy drivers come from multiple sectors.
- **Informational Barriers:** Lack of awareness of benefits of open information among consumers, lack of awareness among "customers" such as public officials about how to implement alternatives.
- **Lack of Cross Sector Implementation:** Solutions that can operate across domains are still not widely adopted.
- **Financial Barriers:** Solutions will require sharing risk between public and private sectors, to capture "diffuse" savings.
- **Unclear Business Case:** Often long payback periods for efficiency investments, lack of incentives from developers, owners and agencies to invest in smart technologies.
- **Behavior Change Unpredictable:** Large scale behavior change possible when financial incentives are there. Citizen and stakeholder engagement for developing demand is a key barrier to overcome.

This slide highlights some challenges cities face. Cities have a complex political, social, and economic landscape.

What is different about an intelligent city?

Knowledge-enabled integration of policy, services, data, and operations.

Public/private ecosystem

Policies & services

Knowledge models

Physical infrastructure & legacy systems

Smart cities use information and communication technologies (ICT) to be more intelligent and efficient in the use of resources, resulting in cost and energy savings, improved service delivery and quality of life, and reduced environmental footprint--all supporting innovation and the low-carbon economy.

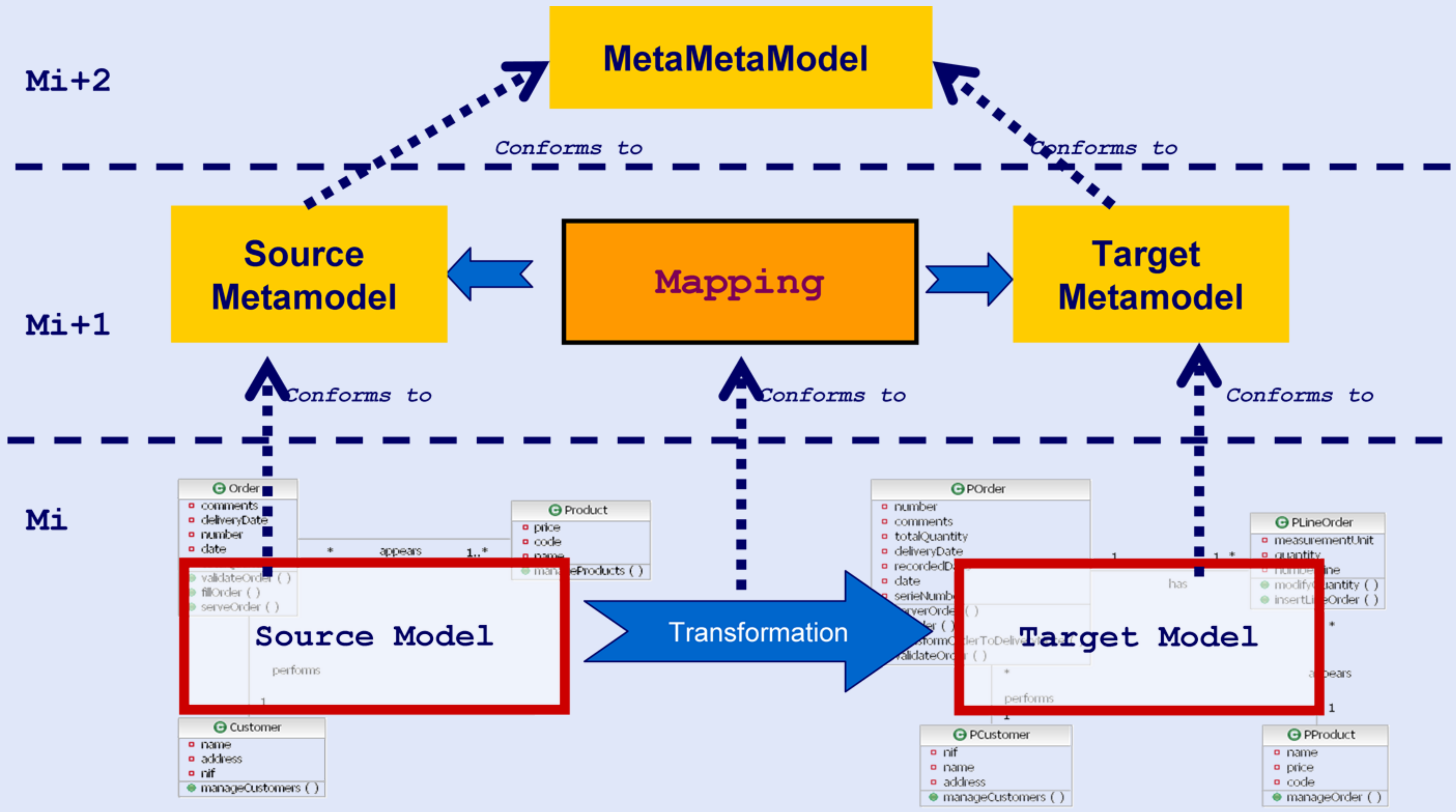
Key characteristics of an intelligent city include:

• Technological infrastructure and an integrated vision are its foundation
• Efficiency and quality of service is improved using new technological tools

• Bidirectional, agile and scalable (up/down) access is enabled among city actors -residents, government and businesses
• A dynamic vision is adopted: change is detected and the city adapts to it in a dynamic fashion, reinventing processes
• Technology is at the service of the citizen, and its application is adapted to their technological know-how
• Solutions to new challenges are produced managing knowledge and supporting creative talent
• Solutions enable access to all residents and make the most of existing talent within connected organizations

What is intelligent city transformation?

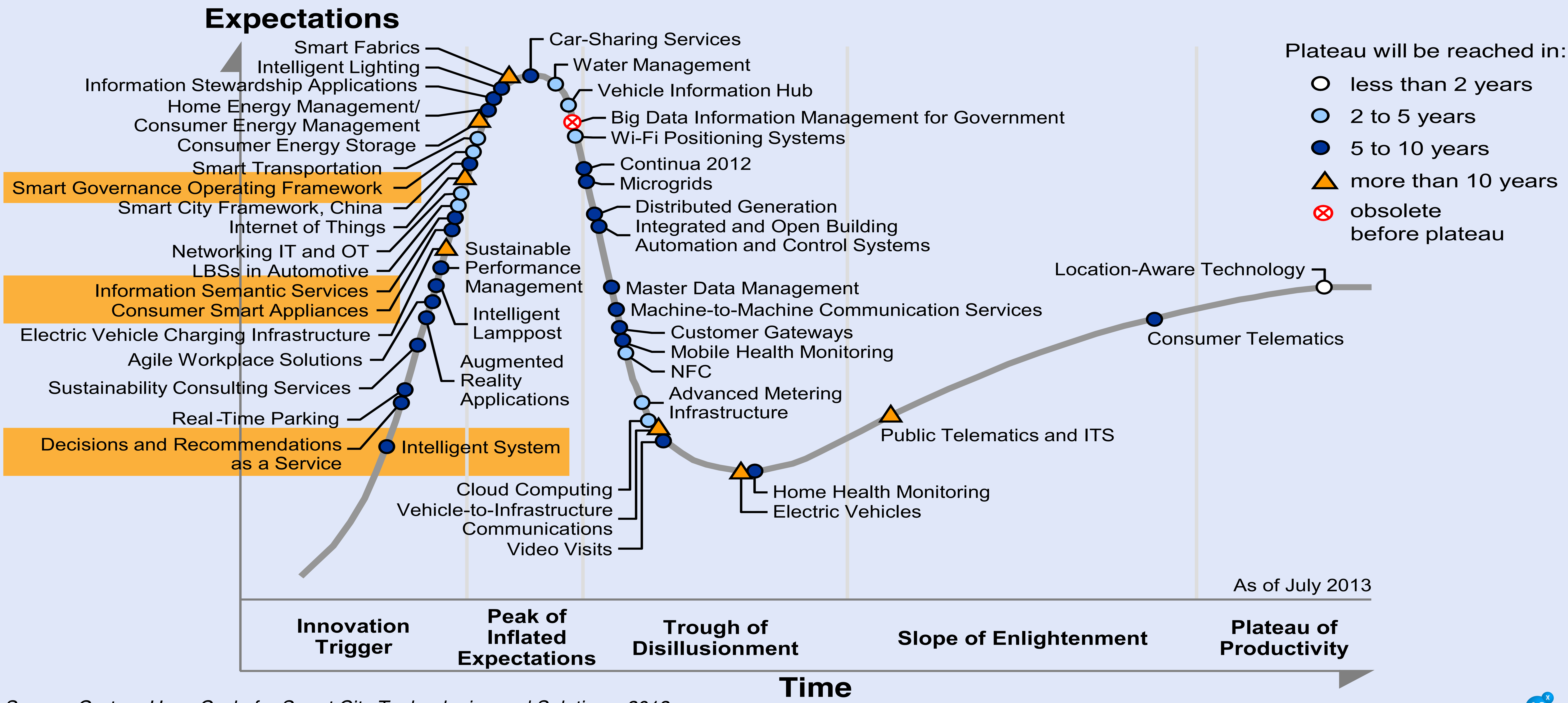
Change that orients the urban center and its regional ecosystem in a new sustainable direction, and aligns people, process, and technology to the strategy for reaching these goals.



This slide provides a definition of urban transformation.

Let’s pause for a second to consider what kinds of technology use make an intelligent city smarter.

What kind of technology makes a city smart?

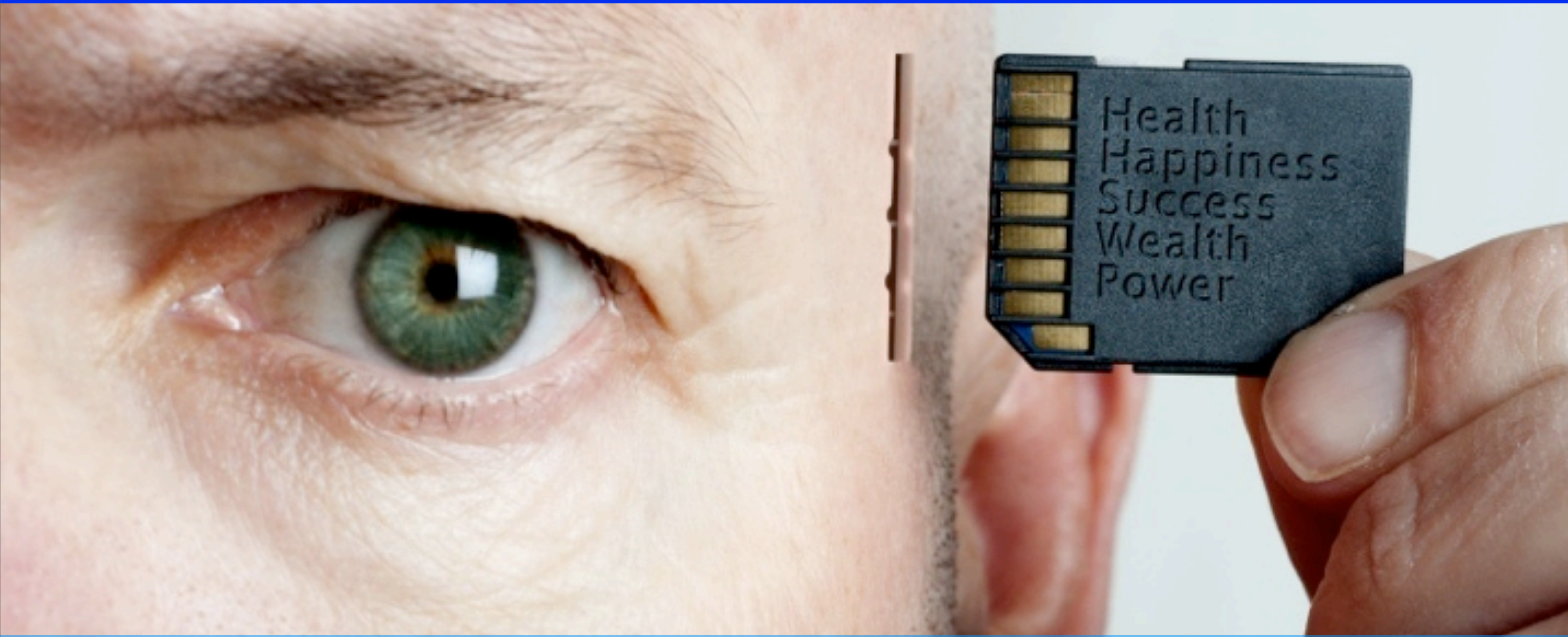


Source: Gartner Hype Cycle for Smart City Technologies and Solutions, 2013

Here is GARTNER's hype cycle for the smart city. I've highlighted a few technologies that appear particularly important for the knowledge science center.

Of course, an intelligent city is more than technology. It is a city that embeds technology into its design and operation. It is a city that integrates across multiple infrastructure layers to drive insights, and focuses on smart service provision for its citizens and business. An intelligent city employs innovative public and private sector partnership and collaboration models.

An important thing about the smart city concept is that it uses intelligent systems to manage common services. The infrastructure needs to be sufficiently flexible so that it can be constantly updated—the very essence of intelligent technologies is the speed at which they evolve.



How do intelligent cities give citizens, companies, administrators, and investors all they need?

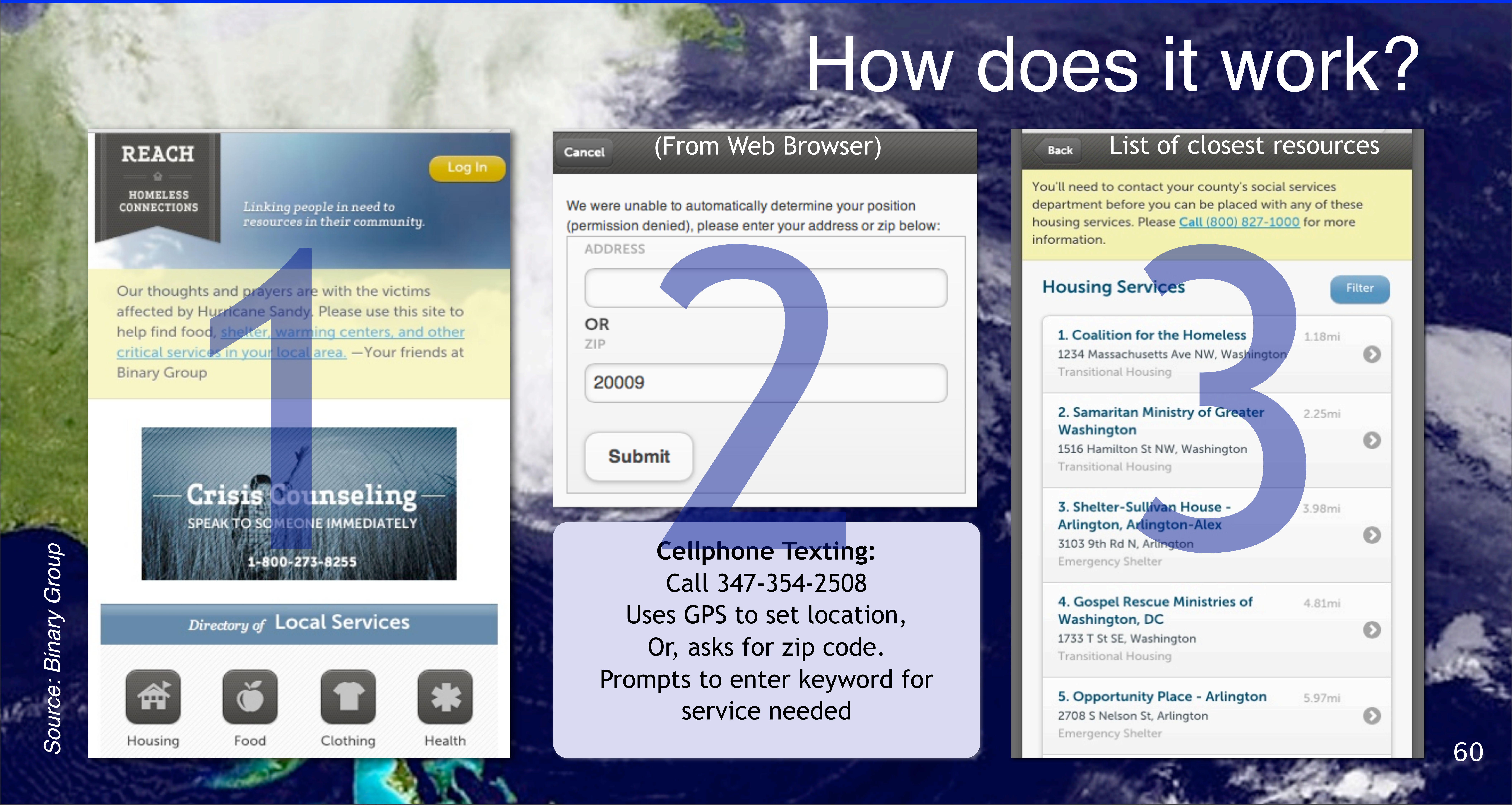
The human capital is in the heart of the process of transformation. Whether people are currently defined as users, clients, or citizens, they all provide the vital ingredients which allow innovation to flourish and to be more effective.

The following series of slides illustrate ways that knowledge science, concept computing, and knowledge management combine to help make a city smarter.

All the examples we talk about are real.

Let’s start with an emergency response scenario and an application that knows how to help people.

How does it work?



Imagine an emergency such as hurricane Sandy. Nothing is working except the cell phone.

How can we help people find shelter, food, clothing, and healthcare?

Just call the number (or click on the app). Key in what’s needed. Get back a list of sources of help organized by what is closest to you.

Intelligent systems -- examples of what can it mean:

Deliver permits entirely online, for over 98% of applications. The system asks only the relevant questions because it knows the rules and regulations to reach desired outcome.

Guide the vulnerable and needy through the welfare maze. Ensure every case has the correct, and most helpful roadmap.

Process compliance automatically in 90% of all cases online. Reduce backlogs and increased fairness throughout the system drives economic development.

Source: Be Informed

The principle of citizen-centric services is to organize the process to make it easy to get what you want. Here are three examples that we discuss in more detail in the following slides.

One-stop permitting: Removing barriers

Over 1Mn Applications.
Consolidated 52 regulations, 1600 forms & 600 agencies

Objective: to reduce administrative burden for citizens and business, improve service, and stimulate economic growth, while protecting core environmental values.

Ministerie van Infrastructuur en Milieu

Intelligent system features:
smart forms, dynamic case management, customer relationship management and policy management capabilities.

RESULTS:
Operational cost reduction € 96 M
Administrative burden reduction of more than € 70 M in year1
Rated 8.5 out of 10 by its users

Economic Development

Source: Be Informed

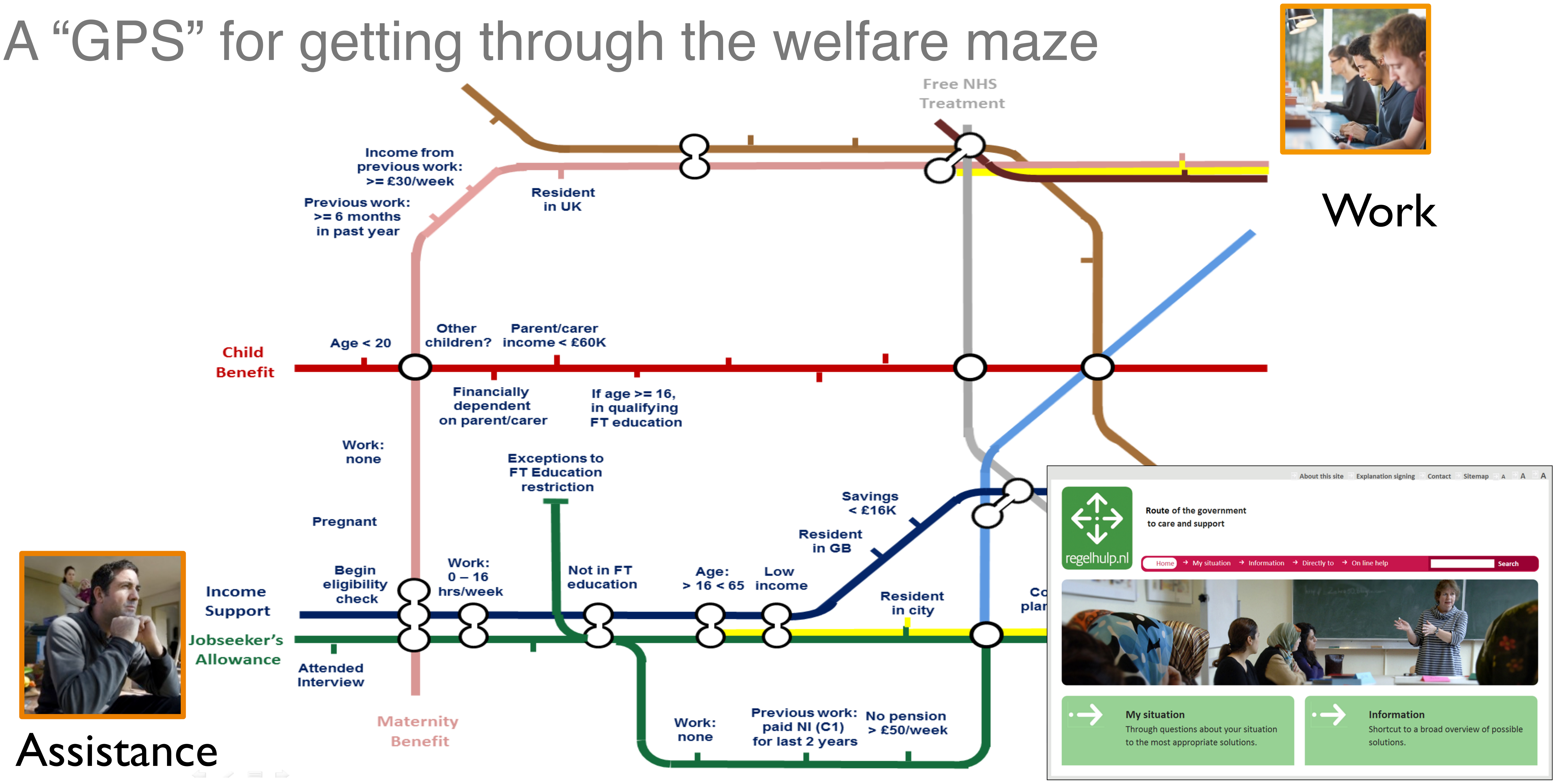
Smart systems help remove barriers. This example illustrates how the a Dutch agency simplified the process of getting permits using knowledge models to integrate 52 different regulations, 1600 forms and the specific procedures of more than 600 agencies and jurisdictions. They made it one smart process.

Instead of citizens having to know all the permits required, and to interact with every agency individually, the system first asked what they wanted to do, and based on this, helped them to gain all of the permits required.

The user experience is simple, helpful. Underneath the models integrate all of the knowledge required.

Not only does the system save citizens time and money, it saved significant administrative costs and reduced burden for the agencies involved.

A “GPS” for getting through the welfare maze



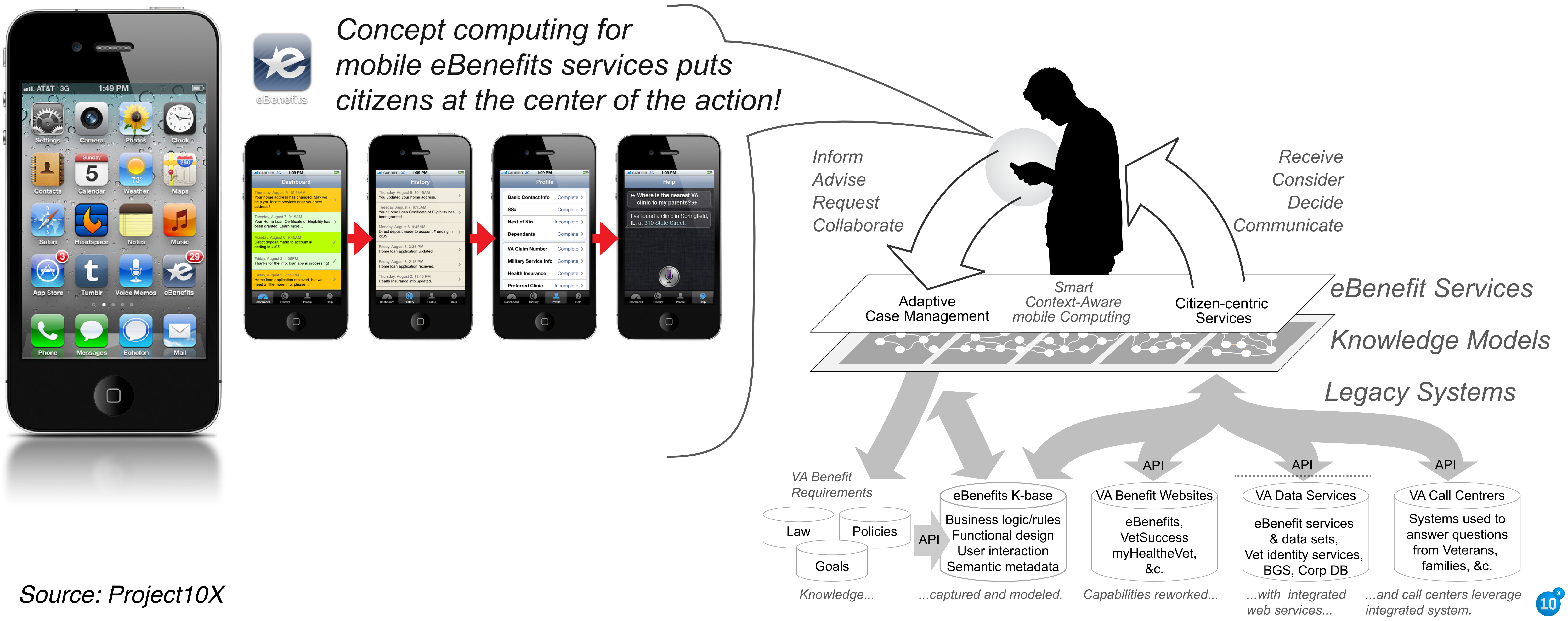
Source: Be Informed

This slide depicts how concept computing and knowledge models can be used to help people navigate complex administrative flows. For example, people with disabilities may be eligible form multiple benefits. Regulations require citizens to re-apply for all programs annually. This was complicated and very difficult for many.

The solution was to model and integrate all of the knowledge of the regulations for all of the programs and create one simple user interface enabling one-stop application, eligibility determination, and benefit fulfillment. Citizens love the program. I had an opportunity to talk with the people who manage the solution. They told me that the program had expanded from 20 programs to more than 60, not counting local variations. They confirmed that, indeed, citizens found the smart system extremely helpful. And, they pointed out other benefits they thought were important. They said that they were abled to handle changes and upgrades to the system themselves...that is, by the people who understood the benefit programs...and that they were doing this without the need for IT training or involvement.

Smart mobile e-benefits:

A “SIRI” to help you get multiple benefits — one-stop self-service, questions answered, helpful advice, and virtual assistance.

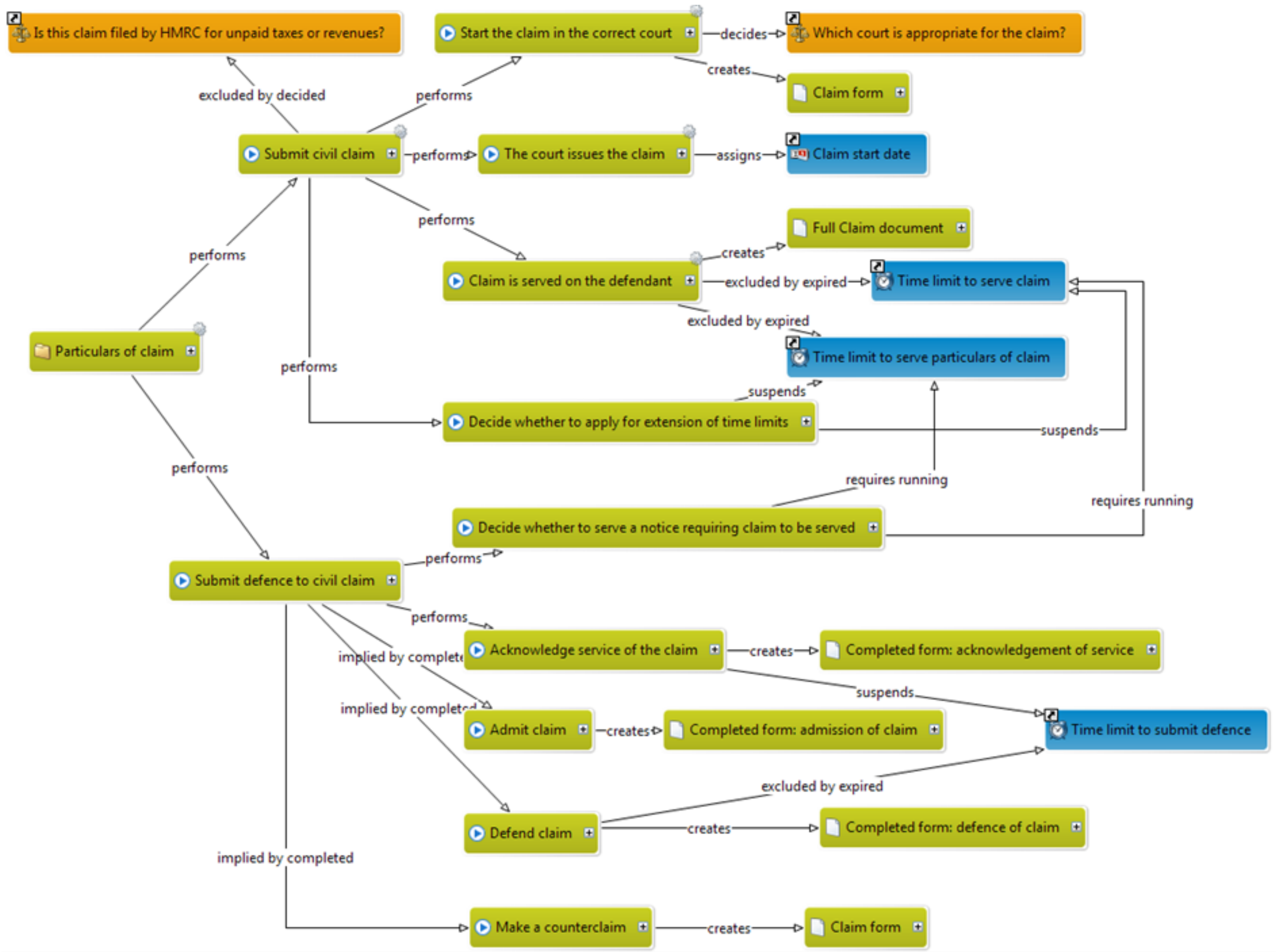


Source: Project10X

Here is another example of what can be done to make smarter services. This pilot was developed to showcase a way to help veterans returning to the states and their families get all the benefits they are entitled to rapidly. At the time, Veteran Affairs was being criticized because the backlog was around 900,000 cases.

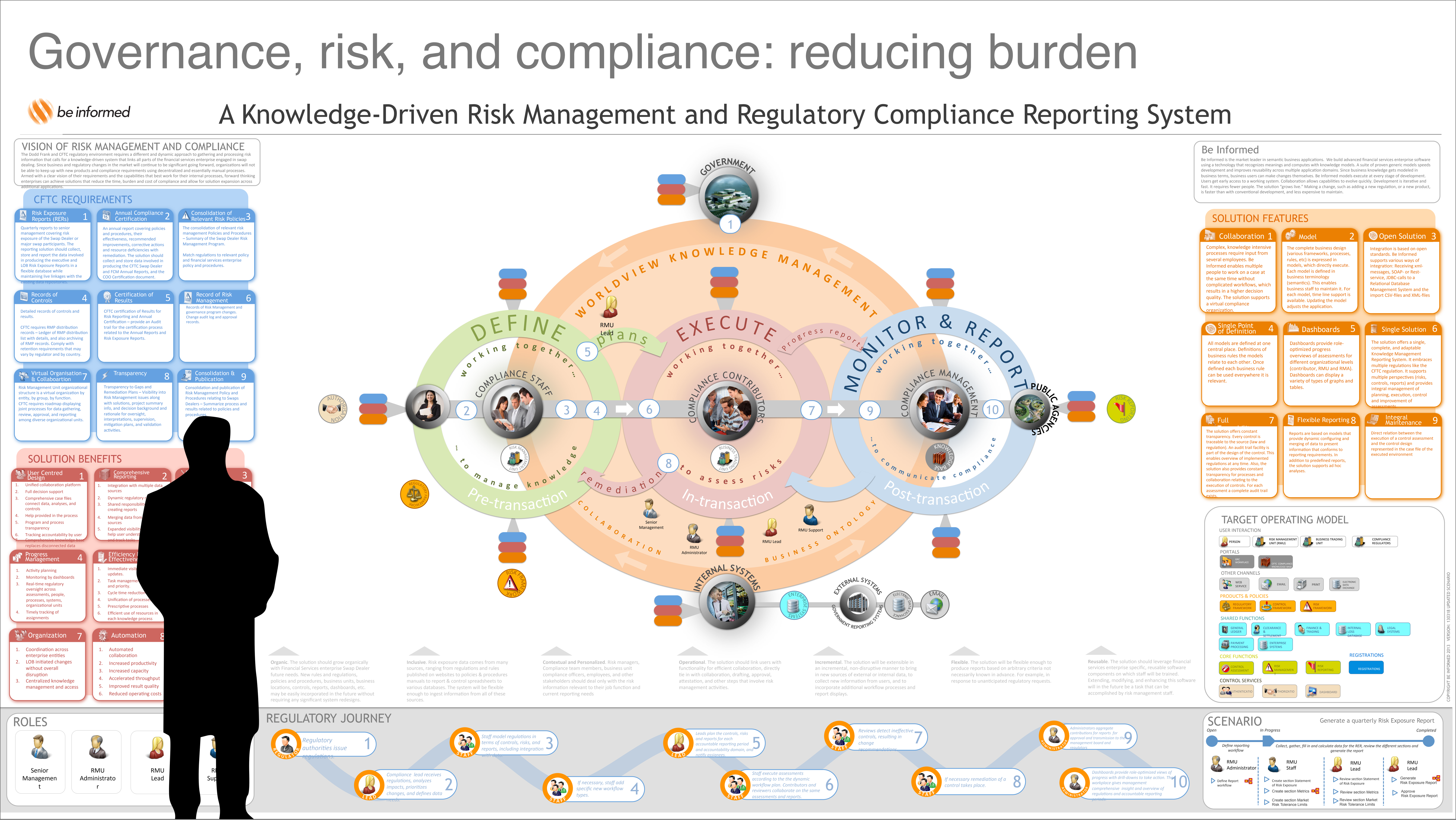
This slide illustrates how the knowledge about all of the benefit programs could be captured, integrated and used to (a) interface with (legacy) applications and databases, and (b) provide a unified one-stop, smart, helpful mobile e-benefits service for veterans and their families that would answer their questions, provide helpful advice, and deliver assistance to determine eligibility and take steps to apply for and obtain benefits.

Fair, legally compliant enforcement process for property disputes



Source: Be Informed

This slide illustrates a model that defines a knowledge-driven enforcement process for property disputes. It shows the process activities and their pre- and post-conditions.



This slide depicts a knowledge-driven risk management and regulatory compliance reporting system, such as would be used by a bank to comply with Dodd-Frank regulatory requirements. If you look closely you will see that the basic architecture is identical to what was shown for the above-the-line architecture in slide-39.

Multi-tax solution — Intelligent process integrates laws & regulations

Interaction channels

- Customer portal
- Administrator portal
- In person
- Call center
- E-mail
- Mobile
- Document input
- SMS
- Data exchange
- Print

Products

- Income tax
- Property tax
- Excise duty
- Regulation & policy
- Corporate tax
- Small taxes
- Risk profiles
- Value added tax

Business functions

- File
- Assess
- Accounting
- Collect
- Reporting
- Pay as you earn
- Pay as you go
- Information & advice
- Correspondence management
- Audit
- Rulings
- Objection & Appeals
- Prosecution & litigation
- Complaints
- Compliance improvement

Registration functions

- Individual
- Tax professionals
- Income & wage
- Property
- Current account
- Tax responsibility
- Company
- Other taxing entities
- Interest
- Value added tax
- Business
- Dividends
- Vehicle

Source: Be Informed

This slide illustrates a basic operating model defining an intelligent process that integrates the laws and regulations for administering different taxes. Concept computing provides a path forward for rapid modernization and for enterprise transformation.

Special thanks to:

www.beinformed.com

The examples just shown are all real. They illustrate the power of knowledge science, concept computing, and knowledge management being applied to make smart enterprises and intelligent government.

What I want to emphasize here is the size of the life cycle benefits that are achieved with these new technologies and methodologies.

Development is typically 3 to 5 times faster and less labor intensive. Concept computing gives enormous leverage here.

Operating costs are less. In these examples the operating costs were lowered by around one-third.

A major benefit of concept computing is that changes and upgrades to a solution are dramatically faster and less labor intensive. Typically, 5 to 10 times faster.

This is the question we are here to explore together. The following slides highlight a few thoughts I recommend we keep in mind as we work to define scenarios and value propositions for KSC stakeholders.

Integrate knowledge science, knowledge technology, and knowledge management.

Transform information and communication technology (ICT) practices through concept computing.

Transform the productivity of knowledge, knowledge work, and knowledge workers by 50X.

Empower cities and their regional ecosystems to compete and grow as vibrant cultural and economic centers.

Assist formation of and transformation to industries, professions, and governance for the knowledge economy.

Let me close with a cautionary slide from the movie Prometheus...

Thank you

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