Evolution of the Information Age: 1960 – 2040

A progress report at the inflection point
of the Cloud and the Web

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ABSTRACT: Over the last fifty years, cycles of disruptive innovation have driven information technology through the emergence of successive technology platforms. Each cycle has disintermediated that which preceded it by dramatically improving productivity, the primary driver of human advancement. I believe that during this decade (2010 – 2020) we will begin to experience the most dramatic inflection point in human history. This will result in the commoditization of information technology driven by the evolution of the Cloud into a commoditized utility which will enable in the emergence of the Web as the new platform of disruptive innovation. The Web will create the pull economy and merge our physical and virtual lives which will ultimately result in an increase in productivity significantly more powerful then the invention of the printing press and both industrial revolutions combined. By about 2040, when the last cycle of the information age is complete, the Web will have set into motion a transformation of life and society upon which humanity will eventually escape the desperation of poverty and the chains of authoritarian governments.

Before I begin, I will take you on a flight of fancy in the form of a blog written after the final cycle of the information revolution in order to provide you with some context.

Bill's Blog: October 16, 2041. What a dream I had last night! It was 2012, before Web Presence or Id (the Personal Identity Assistant implant). I had almost forgotten what it was like back then. It's amazing we kept our sanity when everything was so hard to do in such a chaotic, disconnected world where we were constantly exposed both physically and virtually and where we didn't even have control over our own identity or our personal security. When I think about how close we came to collapse during the cyber security and identity crisis twenty-five years ago, I'm just amazed at how far we've come.

The morning started out as usual. The house woke up with me, Id informed me that everything was ready for the day, that there were no urgent issues or messages to deal with and that I had two hours before my robocar pick up. I put on my retro-design eyeglass style Webview headset, and as I prepared for my run, I interacted with my personal messages and engaged in a cybertable discussion group in 3D avatar mode (Davatar). Using websense I discovered that two of my buddies were also getting ready to run, so we hooked up our Web Presence and decided to do the Aspen Smuggler Mountain run. A good run and having the company was great. While I hit the weights and showered, I streamed my personal newsblogasphere noting that Id had found and secured the last original Bob Dylan vinyl to complete my collection and that my bio-feed had registered some protein and metabolite changes, so my Webdoc had prescribed a couple of genetically engineered mods to my morning nutromed cocktail which I ack'd and drew from the nutrosizer. The

good news was that my weight, hydration, lipids, cardio, immune system and blood chemistry were all in check and after my workout Id had calculated that I had a budget of 2,347 calories left for the day.

While I normally don't have to physically travel much anymore except to hit the slopes (some things just aren't the same in Web Presence, even in holographysic webjection mode), but tomorrow is my seventieth Air Force Academy reunion so I'm heading to Colorado Springs. I'm really looking forward to our rugby rematch with the class of '81. We barely lost to them in '31, but we're in better shape now and we have re-sim'd the game in v-practice many times. Those kids don't have a chance! Id informed me that the robocar was waiting and a ping of my bag showed I needed to add my rugby stuff. Everything else was packed and my bag was booked through to the hotel. At the aerospace port I used my Webview heads-up display to guide me to the suborbital jumper. Along the way I websensed several acquaintances and reached out to a few. It's great that everything has at least an I.D. (an Identity if not a full Web Presence Id) making security a non-issue while giving me control over my identity and privacy. As soon as I boarded the jumper and sat down, the attendant, noting my Web Presence, brought my usual nonfat caramel decaf latte and vegan protein bar (Id subtracted 323 calories). He greeted me by name as Id triggered our last meeting, so I was able to ask: "Hi George how's the novel coming along?" Traveling is so much easier then the "good old days" now that we don't have to bother with baggage, tickets, crowds; check-in, security, boarding lines; delays or even long flights. During the forty minute, thousand mile strato-jump from San Francisco to Colorado Springs, I held a short staff meeting in Webview Davatar mode with local sound suppression so I wouldn't bother people around me.

I'm staying at a new hotel for the reunion, but Webview led me directly to my room which ack'd me, unlocked the door, verified it was configured to my taste, informed me that my dinner would be served as my Id had pre-ordered and that my bag had already arrived. It's really great not to have to carry or worry about keys, watches, phones, computers, cash, credit cards or even identification cards.

Having been invited to attend the Fortieth Annual Tech Awards at the San Jose Tech Museum, I checked out the room's holographysic webjector by having dinner with my wife, Claudia, who's in Aspen tonight. With a free hour before the awards, I sent out a websense ping for any of my classmates at the hotel and met up with a few for a glass of wine. The tech awards ceremony was great. After the ceremony, Claudia and I talked to some Silicon Valley friends, interacted with the exhibits and had an interesting discussion about the de-materialization economy with two Nobel prize winners who were physically there and a professor who was attending holographysically like us. Well, that's about it, nothing unusual today but I'm sure glad we live in modern times where Web Presence gives me "my world under my control"!

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The Information Age at the Inflection Point: The emergence of the cloud of and the web as complementary mega-platforms will represent the greatest inflection point in human history as they unfold over the next three decades. In all of human history there have been only two inflection points in the rate of human advancement. During these inflection points exponential increases in the quantity and quality of communication and in the rate of knowledge creation drove the collective intelligence of mankind resulting in an acceleration of productivity. We are now at the beginning of the third and most significant inflection point. The three inflection points are:

> 1. *The Invention of Language, based on the spoken word.*
> 2. *The Invention of Writing, based on the written word.*
> 3. *The Invention of the Web, based on the digitized word.*

Over the next thirty years, the Web will drive the convergence our physical and virtual lives based on the buildout of the Cloud which will commoditize the Information and Communications Technology Industries (ICT). The effect on individuals is that we will move from a world in which we interact directly, to a world in which we interact physically and virtually simultaneously in a complex, ever changing web of relationships. This will vastly improve our lives but it also has the potential to increase our vulnerabilities. It is my belief that the adoption of user centric identity services will ultimately enable the former and prevent the later, although there will inevitably be bumps along the way.

The purpose of this paper is to describe the processes and technology drivers which are at work and their anticipated technical and economic effects over the next thirty years. While I believe the axiom: "Technology shapes the economy and the economy shapes society", it is beyond the scope of this paper to examine the political, sociological, cultural, moral or ethical implications of these changes which will ultimately dictate both the pace of change and the form of the world order which will result.

1. The Cycle of Innovation Model

Cycles of Innovation are the basis of the model which I have used to evolve this thesis over the last twenty years in order to analyze the past and predict the future evolution of the Information Age. Disruptive innovation is the driver; each cycle begins with the invention of one or more new disruptive technical innovations which are exploited as the cycle progresses and which results in the emergence of a new platform. Each cycle is about thirty years long and is composed of three successive ten year phases. The Information Age will ultimately consist of six overlapping cycles of innovation, with a new cycle starting about every ten years. This model draws in part on Carlota Perez' book: Technological Revolutions and Financial Capital.

> ***Caveat***: *As Peter Drucker maintained: "Predicting the future is pointless, but it is possible to identify ongoing trends that would have significant effects". I believe that this cycle of innovation model is such a trend which has followed the same pattern for over fifty years. In the words of Mark Twain:*
> **"History does not repeat itself but it sometimes rhymes"**

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1. <u>**Cycles of Innovation (Diagram 1, Page 6**</u>) have been the basis for the development and progression of the Information Age which will ultimately consist of six cycles. Each cycle is about thirty years long and includes three successive ten year phases. NOTE: **Cycle Length**: I believe that thirty year cycles are based upon (1) The time it takes for the evolution of a technology into a new product based on a new business model, for it run through the experience curve and finally to evolve into a commodity; and (2) Cultural evolution of the adoption of a new paradyne which I believe requires a generational change.

   - Cycles 1 thru 3 (1960 – 2010) were the invention and development of the Information Technology Platform which over the next ten years or so will culminate in the commoditization of the <u>Information and Communication Technology</u> (ICT) Industries with the emergence of "The Cloud" of on demand utility services.

   - Cycles 4 thru 6 (1990 – 2040) are the cycles of the Internet, resulting in the emergence of the Cloud and the Web Mega-Platforms (Mega-Platforms in that they each evolved over multiple cycles). Each Internet cycle forms a new, higher value of "Web" platform that we will call: Web 2.0, Web 3.0 and Web 4.0. The driver of the Web is that the "ends" (people and things) interact in an infinite number of dynamic relationships extended by application service flows which adapt and respond in service to the ends resulting in the Pull economy and Web Presence.

   - New cycles begin about every ten years during the second phase of the previous cycle; resulting in three overlapping cycles. The first cycle (Semiconductors) began about 1960 and the sixth cycle (Web 4.0) will end about 2040 based on this model.

   - Each cycle builds a new value proposition based on leveraging the value of the technology innovation which emerged in the cycle that immediately preceded it and the commoditization of that which preceded that.
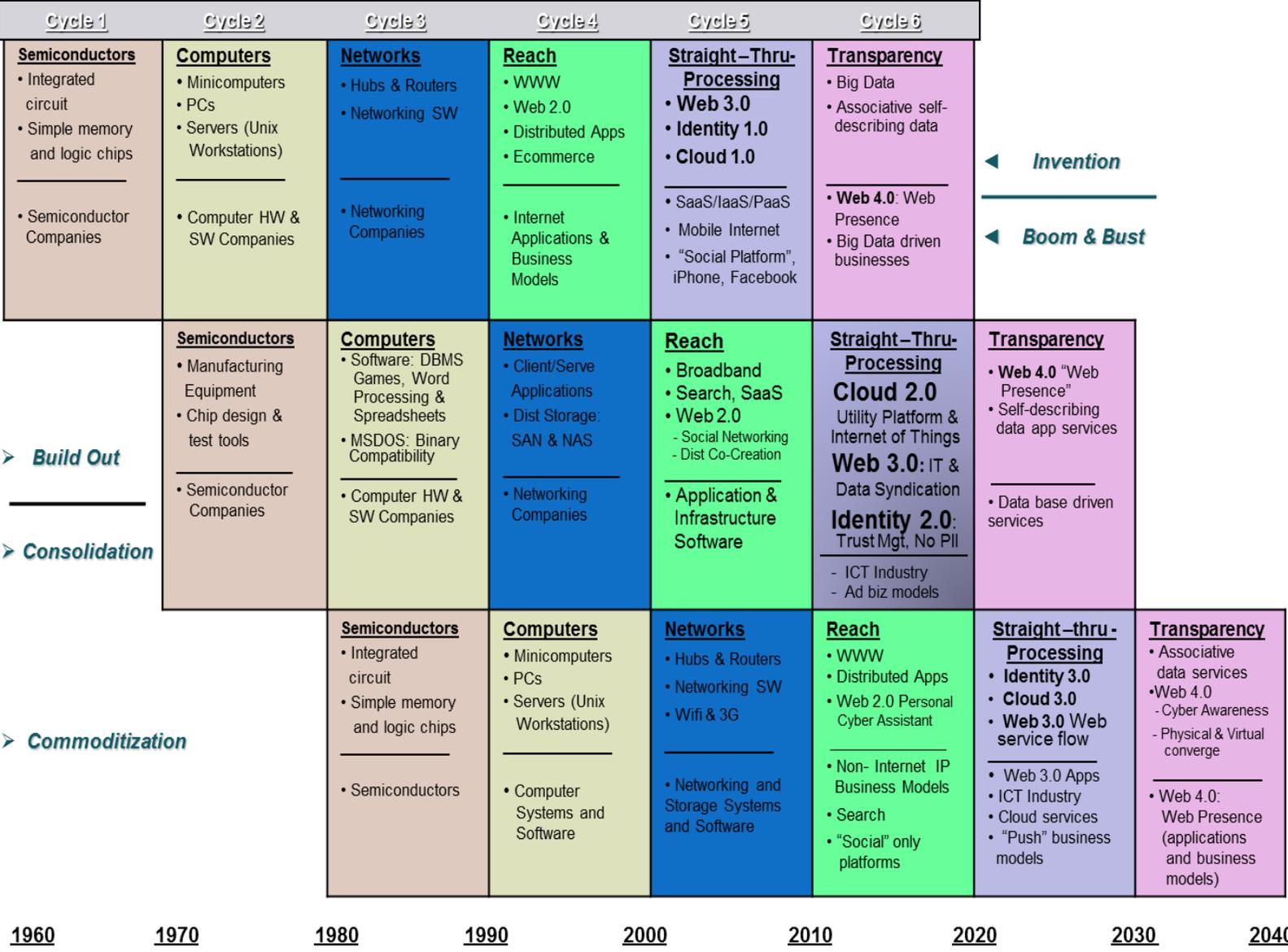
   1.1. <u>**Phases**</u> are about ten years long and cycles consist of three successive phases as follows:

      1. <u>**Invention, Boom then Bust:**</u> The invention of new technology early in the decade leads to a period of over investment based on bubble-like funding of unproven applications of the technology and their anticipated new business model(s) late in the decade. This results in a bust, which has coincided with a recession following every cycle to date.

      2. <u>**Build-Out and Consolidation**</u>: During the first half of the second decade of each cycle the innovation becomes practical once enabling tools emerge and valuable new applications begin to evolve resulting in the technology being widely deployed. (E.g. Once the Internet bubble burst, it was only after broadband - Wifi and 3G - were widely deployed that new applications such as SaaS, Google Search and Social Networking took off). Provider industries consolidate in the middle and latter part of the decade leaving only a few major companies providing safe choices for those that build upon them.

      3. <u>**Commoditization:**</u> The new business model(s) defuse and are the basis for the creative destruction of the model(s) that preceded them as the technology becomes a commodity as prices plummet.

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1.3 <u>Platforms</u> are formed as the result of each cycle of innovation as the cycle's new value proposition emerges and is built out. One or more platforms have emerged during each decade since the beginning of the Information Age. It is part of the thesis of this paper that we are now in middle the final cycle of the evolution of the "Cloud Mega-Platform" (Cycle 5). This is the last disruptive innovation of ICT, and the end of the first cycle of the emergence of the Internet "Web 2.0" (Cycle 4, Social Networking). The Web is the new basis of disruptive innovation for the next thirty years.

- **Characteristics of a Platform**: Platforms have three distinct characteristics which set off a hyper-growth cycle of value creation.

  1. **Commoditization**: The new platform of innovation sits above its enabling technologies and commoditizes them setting off a competitive, cost based declining price and value cycle.

  2. **New Value Creation:** The platform is the basis for creation of a new value proposition which provides the consumer with an order of magnitude better value thus justifying switching cost. This is normally experienced as the evolution of new business models which normally do not appear until the second phase of a cycle.

  3. **Customization**: To be a platform it must provide the capability for the customer to customize it with their personal value and/or competitive advantage. This enables a "long tail" effect to emerge based on extending the usefulness of the platform by adding new applications and/or services for its use.

- **The Personal Computer as an example of a platform**: The modern PC was first successfully commercialized by the Apple with the Apple 2. It included open interfaces for hardware (the Apple Bus) and Software Companies (Apple DOS) to innovate and add value, thus meeting requirement 3 - Customization. It also met the requirement 2 being more than an order of magnitude cheaper than the mainframe or minicomputer. This created a small "network effect" which added value to their computer. But it was still not a platform as it did not meet requirement 1 - commoditization. It wasn't until the IBM PC was introduced running MS DOS that Microsoft was able to: (1) "commoditize" the hardware, (2) thus dropping the cost dramatically by (3) making binary compatibility of software applications possible on any manufacturer's PC that supported MS DOS - the platform finally emerged. This launched a true network effect commoditizing the hardware and providing an open platform for software. Software applications were the basis of the first true "long tail" of the information age as tens of thousands of applications emerged over the next decade covering every market niche and interest group. <u>It is the simultaneous synergistic relationship of a network effect of adoption and a long tail of added value innovations that results in the hyper value creation of each cycle of disruptive innovation</u>.

Cycles of Innovation

	Cycle 1	Cycle 2	Cycle 3	Cycle 4	Cycle 5	Cycle 6	
	Semiconductors • Integrated circuit • Simple memory and logic chips —————— • Semiconductor Companies	**Computers** • Minicomputers • PCs • Servers (Unix Workstations) —————— • Computer HW & SW Companies	**Networks** • Hubs & Routers • Networking SW —————— • Networking Companies	**Reach** • WWW • Web 2.0 • Distributed Apps • Ecommerce —————— • Internet Applications & Business Models	**Straight–Thru-Processing** • **Web 3.0** • **Identity 1.0** • **Cloud 1.0** —————— • SaaS/IaaS/PaaS • Mobile Internet • "Social Platform", iPhone, Facebook	**Transparency** • Big Data • Associative self-describing data —————— • **Web 4.0**: Web Presence • Big Data driven businesses	◄ *Invention* —————— ◄ *Boom & Bust*
➤ **Build Out** —————— ➤ **Consolidation**		**Semiconductors** • Manufacturing Equipment • Chip design & test tools —————— • Semiconductor Companies	**Computers** • Software: DBMS Games, Word Processing & Spreadsheets • MSDOS: Binary Compatibility —————— • Computer HW & SW Companies	**Networks** • Client/Serve Applications • Dist Storage: SAN & NAS —————— • Networking Companies	**Reach** • Broadband • Search, SaaS • Web 2.0 - Social Networking - Dist Co-Creation —————— • Application & Infrastructure Software	**Straight–Thru-Processing** **Cloud 2.0** Utility Platform & Internet of Things **Web 3.0:** IT & Data Syndication **Identity 2.0:** Trust Mgt, No PII - ICT Industry - Ad biz models	**Transparency** • **Web 4.0** "Web Presence" • Self-describing data app services —————— • Data base driven services	
➤ **Commoditization**			**Semiconductors** • Integrated circuit • Simple memory and logic chips —————— • Semiconductors	**Computers** • Minicomputers • PCs • Servers (Unix Workstations) —————— • Computer Systems and Software	**Networks** • Hubs & Routers • Networking SW • Wifi & 3G —————— • Networking and Storage Systems and Software	**Reach** • WWW • Distributed Apps • Web 2.0 Personal Cyber Assistant —————— • Non- Internet IP Business Models • Search • "Social" only platforms	**Straight–thru -Processing** • **Identity 3.0** • **Cloud 3.0** • **Web 3.0** Web service flow —————— • Web 3.0 Apps • ICT Industry • Cloud services • "Push" business models	**Transparency** • Associative data services • Web 4.0 - Cyber Awareness - Physical & Virtual converge —————— • Web 4.0: Web Presence (applications and business models)

1960	1970	1980	1990	2000	2010	2020	2030	2040

Diagram 1: The Information Age's Cycles of Innovation

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2. <u>Cycles 1 - 3: The Information Technology Platform, 1960 – 2010</u>

2.1. Beginning after the birth of the mainframe, Cycles 1-3 constituted the development of the current model of distributed computing that will culminate in the Cloud Mega-Platform during Cycle 5. These three cycles have demonstrated that the Cycle of Innovation model of successive, overlapping thirty year cycles consisting of three ten year phases has so far "rhymed" as Mark Twain remarked. The three Information Technology cycles were:

- Cycle 1: The Semiconductor Cycle   1960 - 1990
- Cycle 2: The Computer Cycle   1970 - 2000
- Cycle 3: The Network Cycle   1980 - 2010

2.2. Cycles 1 – 3 each **<u>extended the reach</u> of computing to a new class of <u>end user</u>**. With the birth of the Internet in the fourth cycle we have extended reach to its final end which makes everyone and everything connectable (Cycle 4).

2.3. I will not discuss these three cycles in detail but will describe The Semiconductor Cycle (Cycle 1) as an example of how the three phases of a cycle unfold:

- <u>Phase 1: Invention Boom and Bust, 1960 – 1970</u>: The invention of semiconductors and the integrated circuit early in the decade led to a boom which resulted in the funding of many new semiconductor companies in Silicon Valley in the latter years of the decade. This boom culminated in a bust due to over-investment in premature technologies and their unproven business model(s).

- <u>Phase 2: Build out and Consolidation, 1970 – 1980</u>: Development of semiconductor manufacturing processes and equipment and the design and implementation of the development tools (e.g. CAD, CAM, In-circuit emulators) required for the development of products which utilized semiconductor chips. Followed in the latter half of the decade by the consolidation of most of the semiconductor start-ups. Note: These developments enabled the invention of the Mini-Computer, the Personal Computer and the Workstation (which ultimately evolved into the UNIX server); during this decade which represented the first phase of the Computer Cycle (Cycle 2).

- <u>Phase 3: Commoditization, 1980 – 1990</u>: Semiconductors became commodities used in the assembly of computers and ultimately virtually all electronic equipment and appliances. Chips rode an accelerated experience curve down to $10 and ultimately $1 or even less. Foundries emerged which accelerated innovation and further commoditized the semiconductor industry.

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3. <u>Basics of The Internet</u>

    3.1. <u>**The power of the Internet is the Internet Triad,**</u>**:** There are three capabilities which give the Internet its power to create value**:** (1) <u>**Free reach,**</u> (2) <u>**Straight-thru-procession**</u> and (3) <u>**Transparency.**</u> This "Triad" is the key concept that forms the basis of innovation for the three cycles of the Internet Platform (The Web Mega-Platform) as it evolves to exploit these capabilities in Cycles 4 – 6, as I will explain in Sections 4 - 6**.** The triad sets off a virtuous cycle of increasing leverage of both network effects and the long tail in a synergistic relationship of increasing value creation. The Web will, however, dramatically increase exposure to personal identity theft, cyber-crime and cyber-terrorism which will require solution to Identity Management. The Internet Triad includes:

        1. <u>**Free reach (Web 2.0 & Social Networking)**</u>: Free reach to the "ends", all ends, everyone and everything is connected or at least connectible. Web 2.0 emerges during Cycle 4 based on free reach to provide a new many-to-many world of social networking. Described in section 4.

        2. <u>**Straight-thru-processing (Web 3.0 & The Pull Economy)**</u>: Providing service on demand through web application service flows (for convenience in the paper I shall call this Web Service Flows) which automatically adapt to meet the needs of the ends through their own role-based identity. Web 3.0 emerges during Cycle 5 by monetizing Web 2.0 resulting in the transformation of the chain of commerce from a mass-market **Push** economy into a micro-market **Pull** economy as the boundaries of our virtual and physical lives begin to blur. Described in section 5.

        3. <u>**Transparency (Web 4.0 & Web Presence)**</u>**:** The leverage of self-describing data with pattern discovery of semantic context and prediction by analogy enabling a goal-seeking **Web Presence** which becomes a personal proxy to adapt the network-of-things in response to the needs and desires of the "ends". The Internet Platform is complete. Described in section 6.

    3.2 <u>**Identity: The fulcrum of the power of the Internet**</u>: Without the element of counter-party trust between those interested in executing transactions on the Web, it is hard to imagine the emergence of the Pull Economy let alone Web Presence. Identity management is the system of claims and attributes which can be asserted and verified by the actors in a transaction that solves this problem. In this context Identity becomes a network of trust providers that authenticate identity and related claims independent of the authorizing party without requiring the release of personally identifying information thus enabling the development of robust, secure commerce on the Web. Key elements of Identity Management include:

        1. <u>**The Identity Management Architecture**</u>: Separation of Authentication and Authorization services. Authentication based on a trust network which can verify identity and claims without exposing any personally identifying information thus enabling security without violating privacy or civil liberties.

        2. <u>**Role Based Identity Services**</u>: Contextual based roles (profiles) whose attributes and assertions are primarily under control of the asserting party. This "User Centric Identity" is based on the fact that individuals have

different aspects of their identity which are important depending upon which role they are engaged in at the time (e.g. employee, patient, student, child, friend or shopper).

3. **Authentication Services**: Multiple-attribute, multiple-pass credential and reputation facilities and authorities independent of the authorizing entity or entities implemented as a trust network which can render Identity anonymous to the authorizing entity unless explicitly authorized by said party.

4. **Cyber Terrorism & Cyber Crime**: Identity is only one element in solving these problems, albeit the enabling element. Among other things the author believes required are: (1) Application code and data cannot permanently reside on self-managed clients; (2) Augmented, embedded network security services; and (3) An international mechanism/organization to coordinate detection, attribution and active defense across legitimate players.

3.3 Emergence of "The Cloud" and "The Web": The Cloud and the Web are two separate and distinct things (Mega-Platforms) made possible by the emergence of the internet triad. "The Cloud" will become the computation, storage and communication utility that provides the commodity services upon which all web service flows are generated, metered and billed on the basis of quantity and quality of service consumed. The Cloud represents the ultimate evolution of the ICT Platform which enables and leads the full evolution of "The Web". The Web consists of the "ends" interacting in an infinite number of dynamic relationships of constantly changing size and organization with and through loosely-coupled web service flows that adapt and respond in service to the ends. As the Web evolves in Cycles 4 through 6, it transforms the economy and extends "presence" across the web blurring the border between our physical and virtual lives and as a proxy to become the prosthesis of life, enabling "my world under my control".

The Cloud Mega-Platform will become the autonomic computing, storage and communications utility which encompasses **OSI Levels 1 – 6,** an on-demand commodity utility service. The Cloud represents the fully evolved, final state of the IT Platform, and the final disruptive innovation of the Information and Communication Technology (ICT) industries which will devolve into a commoditized utility which provides undifferentiated horizontal IP-based services. Cloud 1.0 emerged by 2010 at Amazon (IaaS), Google (PaaS), Salesforce.com (SaaS) and others. Cloud 2.0 will provide more general application and client services as our mobile and online worlds converge during this decade. By 2030 Cloud 3.0 will have fully commoditized the Information Technology Platform and triggered the creative destruction of the ICT industries. In this process, Cloud 3.0 enables and accelerates the evolution of the Web by driving down costs and accelerating time-to-value of Web services. Observations about the Cloud in 2012:

➢ The Basis of the Creative Destruction of ICT: ICT no longer drives of destructive innovation as it has for the last fifty years (end of an era).

➢ Current Limitations: Interoperability, mobility of date and applications, latency, security and reliability.

> ➢ Emerging Technology Enablers: Big Data, Data Analytics, Identity and cyber security, Mobile Applications including HTML5; Interoperable, heterogeneous cloud application development, deployment and management solutions.

> ➢ Framing Observation: Ultimately in a cloud utility world the only critical things to individuals or organizations are: (1) Their Data, (2) Their Identity (3) The security of the first two, and (4) Assurance/Confidence that the cloud and the applications that service the first two are validated to be trustworthy. In this future on the cloud, everything can easily be replaced or changed at will and on demand except one's data and one's identity.

The Web Mega-Platform will become the web of "ends" interacting in an infinite number of complex ways with the aid of Web service flows which enable an adaptive network in service to the needs and desires of the ends in context to the circumstances and situation. The Web is encompassed within OSI Level 7, which is owned, managed and controlled independent of the Cloud 3.0 utility whose services it consumes. In Web 1.0 during Cycles 1-3 services were limited to traditional request-response mode of computing based on direct user to application interaction (e.g. Client Server). It was the dawn of the Internet in Cycle 4 that finally enabled Web 2.0 many-to-many interactions and collaborations based on the free reach to all classes of ends (aka Social Networking). Cycles 5 and 6 will add the power of straight-thru-processing (Web 3.0) and transparency (Web 4.0) leveraged by the power of identity. Observations about the Web in 2012:

> ➢ Basis of Destructive Innovation, B2C monetization resulting in the emergence of the Pull economy (the creative destruction of the Push Economy), the biggest accelerator of productivity in history.

> ➢ Current Limitations: Privacy, identity and security; emergence of business models beyond advertising that serve the ends as micro-markets in realtime.

> ➢ Emerging Technology Enablers: Mobile, Cloud, Identity, Big Data analytics and the Network of Things.

3.4 Cycles 4-6: The Web Platform Evolution, 1990 – 2040: Details sections 4 – 6.

3.4.1 **Cycles of the Internet:** The global economy moves from a push-driven mass market model to a pull-driven micro market model where the ends are in control as each cycle adds the leverage of another capability of the Internet Triad.

- **Cycle 4, Dawn of the Age of Reach, 1990 - 2020**: Free **reach** connects the ends; enabling **Web 2.0** Social Networking and the Network of Things. The final class of end is reached enabling dramatically better value propositions to emerge with each cycle. Web 2.0's economics addresses only the advertising, less than 5% of the global economy.

- **Cycle 5, Dawn of the Pull Economy, 2000 - 2030: Straight-thru-processing** implemented through Web service flows (loosely-coupled

application service-flow mash ups) and Identity management enabled by the emergence of the Cloud adapts to the demands of the Ends as the **Web 3.0 Pull Economy** emerges. Web 3.0's economics extends through the entire chain-of-commerce enabling it to address most elements of the global economy, dramatically increasing productivity.

- **Cycle 6, Dawn of Web Presence, 2010 - 2040**: Data **Transparency** enabled by semantic pattern discovery and context-sensitive data services adapt the environment to the needs and desires of the Ends in context to their situation and circumstances. Transparency is further leveraged with the enhancement and extension of Identity Management Services. Services are extended to include goal-seeking capabilities which can be projected over the net as a proxy for the individual, **Web 4.0 Web Presence**.

3.4.2 **Result**: **The Web becomes our prosthesis of life; the most important human invention since mankind learned to use language**.

- The reinvention of commerce, from a push to a pull model, moving from mass to micro-markets as the long-tail dominates value and value-creation enabled by the network effects of the Web (The Internet Triad).

- The Web of "Presence", "Identity", "Places" and "Things" in service to the "Ends" accelerates globalization and greatly increases productivity resulting in the addition of billions of people to the middle class while improving the quality of life for all.

3.5. **Catalysts, 2010 - 2020:** Proliferation of Mobile Devices, Big data analytics, the Internet of Things and Open Source will be the enablers of Web 3.0 and be the catalyst of Web 4.0.

3.5.1. **Mobile**: The Platform for client engagement.

- Mobile devices will evolve into prosthesis for living in society with the implementation of Identity and the Network of Things for our engagement in the converged virtual-physical world over the next three decades.

- Geolocation and digital exhaust enable social monetization.

3.5.2. **The Network of Things:** Everything becomes instrumented and online, massive opportunities emerge, data volumes explode (every "thing" has its own weblog) and the disruption will accelerate, extending the platform to include engagement with (and in many cases control over) the environment in which we live.

3.5.3. **Big Data**: The ability to mine data about everyone and everything in realtime will change the dynamics of business, relationships, politics and society. This is the basis of the "killer applications" that will emerge this decade and into the next.

- Emerging Technology Enablers: Mobile Apps (HTML5), Network of Things, Big data analytics, self-defining data and discovery of ontology's.

- Limitations: Security, privacy, walled garden carrier plans.

3.5.4. **Open Source**: Software and hardware that break control points. Like Android and iOS are attaching the Microsoft's application control point on the PC. This coupled with the Cloud is blurring the line between consumer technology and enterprise technology, success on one will roll over to success in the other.

4   Cycle 4: The Dawn of the Age of Reach, 1990 – 2020

Free reach, the first capability of the Internet Triad, was enabled by the invention of the World Wide Web in the 1990's which ended with the bursting of the internet bubble eleven years ago. It then gave birth to Web 2.0 once broadband was widely deployed in the first half of the last decade (the build out phase of Cycle 4). Web 2.0 applications began to become a platform in 2007 when Facebook opened their site to applications and Apple introduced the iPhone App Store. This led to a buildout of social network applications which are just now beginning to be monetized beyond advertising through the Cycle 5 Pull Economy (Section 5). During the current decade, as networked devices proliferate (e.g. smart phones and pads), consumerization of IT emerges and our mobile and online lives begin to converge, these reach enabled, always-on, always-connected capabilities will begin to merge our physical and virtual lives.

4.1   Phase 1: Invention, boom and bust   ~ 1990 – 2001

- **Invention**: Began with the invention of the World Wide Web (WWW) as Cycle 3 networks were built out and widely deployed, data was distributed and distributed enterprise applications emerged.

- **Boom**: The Internet bubble (1998 – 2001): WWW, J2EE/.NET, Web Services, Application Integration, Portals and the vision of adaptive applications (SOA). Massive investment in "Dot.Com" companies.

- **Bust**: We busted (~2001) due to an over-investment in technology and premature Internet business models (e.g. ASP, WebVan, and SFA).

4.2   Phase 2: Build out and consolidation ~ 2001 – 2010

- **Internet Buildout 2001 ~ 2005**: Broadband, Wifi, 3G, IM and Search, were widely deployed and Enterprise Applications and Infrastructure software becomes "Good-Enough". This buildout enabled the emergence of SaaS, Google, Amazon EC2 and Social Networking (Web 2.0). **Consolidation:** Consolidation of PC, Server, Software Infrastructure and Application providers and even some of the early leaders in social networking.

- **WEB 2.0 "Social Networking"**: The first generation web platform build on the Internet Triad emerges. Based on the leverage of reach, Web 2.0 enables the multi-dimensional peer-to-peer, linked-in, social-networking collective to emerge. In 2007, when Facebook introduced its application strategy and Apple introduced the iPhone App Store, Web 2.0 finally became a platform with the advent of customization in the form of open interfaces for applications leveraging innovation out to the long tail. Note: Web 2.0's application of reach addresses only a few percent of the global economy through advertising. Extending this to reach the rest of the economy will require Cycle 5 to address straight-thru-processing and Identity to enable the leverage of Web 3.0 Pull Economy monetization.

4.3 Phase 3: Commoditization of Web 2.0, ~ 2010 – 2020

As our virtual and physical lives converge, an always on, always connected Social Networking platform emerges leveraging the essentials of our daily lives (e.g. where we are, what we are doing, who we are with, who we know, what we want, what we are planning and what's happening). These social platforms commoditize the networked services and tools that preceded them such as: (1) Productivity Applications, (2) Collaboration Applications, (3) Email, and others to begin to form a "Dashboard" for life which will fully evolve in Cycle 5 with Identity and the Pull Economy. This will expose us to more risk and speed the obsolescence of the current Data Center and Desktop based computing systems and services driving Cloud and Identity in Cycle 5. Drivers of this commoditization include:

- **Monetization**:

  - Digital Exhaust: Our lives are exposed, what we do, where we are, who we know what we are planning and any other and related information is exploited in the quest to monetize social networking, massively increasing security risks. Please note this will be partially enabled by sensor proliferation, geopositioning and rich client services based on HTML5.

  - The Economics of Advertising: The economic drive to monetize our real time data exhaust to better target sales opportunities, the "last mile" of advertising by doing micro-targeting of individuals in context to their current circumstances and history.

- **Convergence of Services**:

  - The Triple Convergence: Voice, Data, Video converge into IP based services. Everything is generated on "servers", stored and distributed over IP networks which will be transparent inside Cloud (Cycle 5).

  - The Quadruple Convergence: Extends the triple convergence as the distinction between our online and mobile experience disappears. This will culminate in an always on, always connected, flat IP-Based world (the Evernet). Please note that this will be partially enabled by: (1) IPv6 making it possible to bring everything onto the network (The Network of Things), (2) by Mobile 4G taking IP services over the last mile to mobile devices and (3) by the proliferation of client devices.

- **Reach to All Ends**:

  - Consumerization of IT: The boarders between the enterprise and the "wild west" of the internet fall as devices proliferate and our mobile and on line experiences converge.

  - The Network of "Things": Everyone and everything become connectable and increasingly connected. Devices, sensors and actuators proliferate and all become part of the Evernet.

  - End Point Security: Without Identity Management end point devices which are self-managed and contain either permanently resident data or application code become insecure.

5. Cycle 5: Dawn of the Pull Economy (Web 3.0), 2000 – 2030

This is the most important cycle of the Information Age. The inflection point in productivity growth will begin during this decade (2010 – 2020) as The Cloud and The Web reach critical mass together. These two Mega-Platforms will drive an unprecedented set of dislocations and consolidations resulting in the greatest leap in productivity in human history over the next several decades. Web 3.0 is the disruptive innovation platform of Cycle 5, it will ultimately commoditize the mass-market, push-based economy by leveraging straight-thru-processing; the second capability of the Internet Triad, to enable it to adapt to the needs and desires of the ends across the chain-of-commerce. The Web, therefore, extends the power of reach by adding adaptive, policy-based, event-driven web applications (Note: For convenience I will call this "Web Service Flows")**.** This will lead to the build out of the Pull Economy and the commoditization of the Push, mass-market economy, but it will require the simultaneous build out of: (1) The Cloud Mega-Platform, (2) Web Service Flows and (3) Identity Management.

1. **The Cloud Mega-Platform**: The autonomic compute, storage and communications utility which commoditizes ICT into Scott McNealy's "dial tone" (see "IT Doesn't Matter" Nicholas Carr, HBR May 2003)**.** The Cloud is the final disruptive innovation, and thus the mega-platform of ICT. Competition in a global, open market for undifferentiated IP-based services drives pricing down and forces consolidation to a handful of global suppliers. This disintermediates and commoditizes the, IT systems, IT services, Telecommunication services and System Software Industries.

2. **Web Service Flows**: Web 3.0 will be monetized through the assembly and ultimately auto-assembly of loosely-coupled web service flows of composite applications (e.g. Scripting, Cloud Services, HTML5, SOA, BPM, etc) mash ups, techniques, tools and data services with identity, social networking and personal contextual capabilities**.**

3. **Identity Management:** The fulcrum of the Internet Platform that launches Web 3.0 by enabling the level of counter party trust necessary to allow transactions to be securely and safely implemented across the internet. This launches the Internet Economy by monetizing it beyond advertising eventually extending across all aspects of the economy. With the emergence of Identity, the internet of position-aware, self-identifying things will be built out, accelerating the pace of change while enabling the Pull economy. Please note: The Federal Government's National Strategy for Trusted Identities in Cyberspace (NSTIC), announced in April 2011 is based on this principle of a trust network.

5.1   Phase 1: Invention, boom and bust ~ 2000 – 2010

- **Inventions:**
  - o **Web Service Flows:** Mash ups across Web 2.0 platforms, personal productivity and collaboration tools emerged (e.g. Kapow) but were not widely adopted or standardized inhibiting the monetization of Web 2.0

thus the value proposition did not justify the switching cost of Internet Commerce.

- o **Cloud 1.0**: Available from Amazon, Google and others. It was proprietary, locked customer in, required applications to be developed specific to their environment and provided limited, web facing capabilities. Services include: (1) IaaS - Amazon EC3, (2) PaaS – Google and (3) SaaS - Salesforce.com. Neither a platform of a utility.

- o **Identity 1.0**: Attempts were made to centralize identity (e.g. Passport, Liberty Alliance, I-Card) all of which failed as they did not meet the laws of identity ([Kim Cameron's Laws of Identity](#)), and because they disintermediated parties in the chain of trust and/or they required exposure of personally identifiable information. Progress was made as social networking sites were forced to adopt role based privacy mechanisms, the first generation of identity management.

- o **Web 3.0**: During the last decade Social Networking emerged and blossomed into an enormous network effect as Myspace, LinedIn and many other [Social Networking Sites](#) emerged, but it was not until 2007 when Facebook published their application programming interfaces (APIs) and Apple introduced the App Store that the platform began to emerge.

- **Boom**: There was a minor boom in investment in social networking over the last two years which was delayed and severely limited by the great recession. The relatively small segment of the economy addressed as Web 2.0 platforms were not able to be monetized directly for their own value and were thus limited primarily to advertising. Initial attempts to monetize content and services directly (e.g. video, news, etc.) met with limited success. A few unique Web 2.0 sites are finally now exploding in value (e.g. Facebook, LinkedIn, Groupon, Pandora, and Twitter) and the bubble is finally forming as companies rush to the IPO market to take advantage of the hype. A unique aspect of this boom is that in most social networking segments there will be only one winner (a power law distribution). This will not stop many copycat companies from leveraging the bubble.

- **Bust:** This was the "lost decade" for venture capital investments, and therefore the investment boom was relatively small. The bust is late due to the great recession delaying the IPO frenzy which is now happening. The bust seems to be happening for those companies that have not created a sustainable revenue growth model, but it will be relatively small due to the investment made during the last decade and the small segment of the economy involved (advertising).

5.2 Phase 2: Buildout and consolidation ~ 2010 – 2020

- **Buildout**:

  - **Web Service Flows:** The mechanism for the implementation of web application service flows comprised of loosely-coupled, composite application services in "mash-ups" which automatically adapt to policy and identity to meet the needs of the ends in context to their situation. As

Web 3.0 matures (in phases 2 and 3) everything becomes a service that can be "mashed-up" and delivered on-demand across any combination of entities on the Web in service to the needs and desires of the ends.

- **Cloud 2.0:** Will extend Cloud 1.0 applications and services to include more complex multi-tier applications and workflows where private clouds become a standard part of enterprises and converge with public clouds. Connectivity and mobility of applications and data between internal and/or external clouds becomes the defacto standard offering. By the end of the decade, IaaS wins as the cloud platform with PaaS and SaaS as added value services supported by the commodity IP services provided by IaaS vendors. The client (Client-as-a-Service) becomes the common end point in order to leverage any device securely as our online and mobile worlds converge. Cloud services become generic, undifferentiated IP-base services driving prices down relentlessly by the end of the decade. Cloud 2.0 becomes a Platform but not yet a Utility.

- **Identity 2.0:** Identity becomes the basis of "Trust" throughout the Web 3.0 chain-of-commerce. It is the evolution of Identity as a trust network separating authentication from authorization which launches the Web 3.0 boom. Over the next thirty years Identity will be extended to include and ultimately learn and adapt policy, preferences and experiences which will allow one's personal "presence" to be extended over the web as a proxy. The key elements of Identity services are:

  o **Role Based Personal Profile**: A role-based, context-sensitive personal profile system implements User Centric Identity. As Cycles 5 and 6 proceed it will be extended to include situation-dependent, goal-seeking capabilities which in Cycle 6 extend "presence" onto the web and become a proxy for life.

  o **Trust Network**: Separation of Identity, Authentication and Authorization into three separate facilities is the key to counter party trust and risk management. The relationship of Identity and Authorization is one of risk management based upon the trust in authentication services. Authentication services (the Trust Network) are the multiple-attribute, multiple-pass distributed credential and reputation facilities and authorities which are independent of and often transparent to the authorizing entity or entities. This authentication trust network will render Identity anonymous or pseudo-anonymous (e.g. exposing only required attributes) to the authorizing entity unless explicitly allowed by the owner of the identity or by appropriate authorities. Where tradition security systems become weaker as more parties participate, the trust network grows stronger insuring security while maintaining both privacy and civil liberties.

  o **Client Security**: Security and integrity of the client device will be required to implement this system of trust which implies a thin client that cannot be compromised. I believe that this can only be

achieved if self-managed clients do not permanently store data or applications, therefore requiring cloud services.

- **Web 3.0**: Becomes a platform supporting the on demand internet pull economy as Web Service Flows, Identity and The Cloud build out. As mobile and online converge, the Web 3.0 platform evolves and extends to an ever expanding number of commercial opportunities in context to the situation where:

  o The Ends become empowered by leveraging Straight-thru-processing to adapt, change and evolve beginning with simple mash ups for Web 2.0 facilities.

  o Self-forming, self-adapting communities, value chains and economies emerge and extend out to the long tail.

  o Pull business models evolve making it possible to leverage the majority of the economy beyond advertising.

- **Consolidation:** The creative destruction of ICT.

  - **Communications Service Providers** will evolve into generic Cloud Utility Service Providers which sell undifferentiated IP-based services on-demand and which are transparent from and interchangeable by the consumer. This is the result of the convergence of all Telecommunications Companies, Cable Companies, ISP's and IT Outsourcers on a global basis. A small number of suppliers (e.g. 4 - 8) will service the majority (+/- 80%) of global market by about 2030. The competitive pressures that drive this consolidation are:

    1 The cost of generating incremental capacity approaches zero driving pricing downward, thus requiring large scale economics to compete.

    2 A global market without natural boundaries or boarders increases the level and speed of consolidation further driving scale economics.

    3 Network effects of a commoditized, undifferentiated, general purpose market accelerate economies of scale in a zero sum game.

    4 Scale of economics and the ability to take consolidation risk favor the largest Telecommunications and Cable Companies and possibly Google, IBM, Microsoft and Amazon.

  - **System Infrastructure:** The compute server, storage, and network manufacturers will consolidate into a handful of system infrastructure providers (hardware and all infrastructure software) who sell to the Cloud Utility Service Providers which represent the vast majority of their global market (this consolidation will continue well into the next decade but will be well underway by the end of this decade). The resulting industry will resemble that of the telecommunication equipment industry which includes only a handful of major global suppliers. Almost everything they sell will become generic, low margin, commodity products with little differentiation resulting in cost-based commodity pricing. During the current decade networking and storage will be commoditized as their added value is implemented in software defined architectures.

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o **Software Defined Network**: Based on the control plane standard Openflow promoted by the Open Network Foundation, it separates the network operating system (NOS) from the network switches and routers and extends to include a Level 2 and Level 3 application interface architecture. This architecture will become an open standard compatible with current networks. With open APIs it allows added value services and the implementation of commodity switches and routers. This is in use in many research universities today and being promoted by several well funded startup companies including Nicira recently acquired by VMware.

o **Software Defined Storage**: The disruptive innovation for cloud storage is the emergence of the distributed software defined storage network architecture. This is accomplished by implementing a distributed storage network based on commodity disks and policy driven storage control plane software to redundantly store data across the network and enable value added storage applications. By doing this, software defined storage networks implement all primary storage requirements through policy and added value application, including: security, backup, archiving, disaster recovery, high availability and edge caching.

- **IT Outsourcers**: Outsources will evolve into, be displaced by or be consolidated into Cloud Utility Service Providers as their current value-based pricing model is disrupted by the order of magnitude better cost-based commodity pricing model of generic, horizontal Cloud Utility Cloud Services.

5.3 Phase 3: Commoditization ~ 2020 – 2030

- **Web Service Flows:** Web service flows become self-forming and self-optimizing applications servicing the needs and desires of the ends in context to the circumstances and situation. The Pull micro-economy is enabled at the expense of the mass-market, mass-production, capital-intensive push economy through real-time mashups of systems, content and services.

- **Cloud 3.0**: The Cloud is finally both a Platform and a Utility. The Cloud Mega-Platform will begin to emerge by 2015 and be ubiquitous by 2025. The Cloud as a utility will provide capacity-on-demand at commodity prices where suppliers are interchangeable on demand and where the consumer owns and controls their identity, policy, workflow, data and intellectual property. Enterprise data centers become private cloud extensions of public clouds with declining LAN-connected islands of historical legacy applications. Cloud 3.0 meets the requirements of a utility:

o **Isolation of Supply (OSI 1-6) and Demand (OSI 7):** Just as the adoption of alternating power commoditized electrical generation allowing it to evolve independent of demand thus

dramatically increasing capacity while drastically lowering pricing, Cloud 3.0 will similarly set off the creative destruction of the ICT Industries.

- o **Metered Billing**: Customer metering of usage and billing based on the quantity and quality of capacity utilized. The meter will measure based on the customer's utilization not on the supplier's resources consumed.

- o **Customer Ownership and Control**: Customers control how they utilize capacity based on their desired output, not on server, storage or bandwidth utilization. The customer owns their IP (e.g. policy, work-flow, data, identity and in many cases proprietary software) and can change suppliers on demand.

- **Identity 3.0**: Identity is the basis for internet commerce, it is ubiquitous and forms the foundation of our dashboard for life allowing our virtual and physical lives to converge and supporting individual proxy services. Identity enables security while protecting privacy and civil liberties.

- **Web 3.0**: Commoditization enables the reinvention of commerce as we know it through the power of Pull, the killer application of the Internet! Creative destruction of the mass-market push economy occurs as the synergies between the network effects and the long tail dominate and increasingly accelerate the rate of change. The search industry is commoditized by the leverage of identity and the role-based goal seeking capabilities it evolves to include.

- **Creative Destruction of the ICT Industry**: Cloud 3.0 represents the final state of evolution of the IT Platform which will result in the commoditization of the products, services, business models and pricing of all ICT industries as we know them today. This commoditization actually begins during the second half of Phase 2 (2015 – 2020) in three segments of ICT: (1) Communications Service Providers, (2) Computer, Network and Storage Providers, and (3) IT Outsourcers. In addition the software industry commoditizes and consolidates:

  - o **Application Software**: Most horizontal enterprise and productivity applications will disintegrate into loosely coupled generic services which will become part of the commodity infrastructure as Web Service Flows emerge and are built out in an evolutionary way. This will be accelerated through open source and generic, good-enough horizontal application services provided by Cloud 3.0 Utility Service Providers as they move up the value chain to capture value and account control.

  - o **System Integrators and Software Developers**: SIs and software developers will evolve into Web solution assemblers and/or component vendors as they move up the value chain to provide value through a combination of: (1) assembly time-to-value; (2) content and (3) vertical market domain knowledge.

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6. Cycle 6: The Dawn of Web Presence (Web 4.0), ~ 2010 – 2040

The ability to turn "[noise into signal](#)" is achieved by leveraging data transparency; the third and final capability of the Internet Triad which, in turn, enables ones presence to be extended over the web as a proxy thus becoming the prosthesis of life with Web 4.0, the final step in converging our physical and virtual lives. By automatically adapting the transparency of real time data in the internet of things to the needs and desires of the end users in context to their Identity, their situation and their personal needs, desires and experiences, the Web truly becomes the prosthesis of life delivering "my world under my control". Technology as we know it becomes invisible to end users as it learns and adapts to us. It is my assumption that a direct neural interface to the Web will be in common use before the end of Cycle 6 thus changing everything about how we learn, interact and live in our fully connected world where the collective intelligence of mankind is available securely while honoring personal privacy and civil liberties.

6.1 Phase 1: Invention, boom and bust ~2010 – 2020

- **Inventions:**
  - o **Big Data and Big Data Analytics:** Big Data will be extended with the invention of self-describing, self-identifying data representation based on semantic pattern (e.g. Ontology) discovery capabilities and goal management facilities which leverage and extend personal profile identity systems.
  - o **Web Presence**: Identity management will be extended to include role-based goal-seeking, context-sensitive facilities. Note: Traditional data base models are not capable of meeting these needs as they set limitations on how data will be "associated", extended and adapted by their methods of storage; therefore an associative data technology with pattern discovery will emerge to address it.
  - o **Web 4.0:** Self-forming, self-adapting services which leverage transparency and automated goal-seeking technology to meet the needs and desires of the individual (The Ends) in context to their current role, desires and circumstances.
- **Boom & Bust**: This will result in a boom and bust from over-investment in pre-mature Web 4.0 technologies and business models.

6.2 Phase 2: Buildout and consolidation ~ 2020 – 2030

- Buildout: Goal-seeking adaptive services and associative memory data services and extension of Identity services will enable Web Presence. This will be based on associative memory data service technology processed through predictive outcome algorithms based on historical pattern recognition (the potentially the killer application for quantum computing).
- Consolidation: The last vestiges of the mass-market, push-based economy.

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6.3 Phase 3: Commoditization ~ 2030 – 2040

- Pull economics which enable my world under my control and vastly accelerates productivity creating a world where war and poverty become less and less common.

- By about 2040, when the last cycle of the information age is complete, the Web will have set into motion a transformation of life and society upon which humanity will eventually escape both the desperation of poverty and the chains of authoritarian governments.

7. **Dawn of the Age of De-materialization**: The next four to six cycles of innovation will be driven by the nexus of Nanotechnology and Biotechnology. At the molecular level there is no difference between physical and biological and that is where we will change the definition of the world(s) we live in and the boundaries we live between.   The first cycle should begin around 2020 assuming they continue to "rhyme**". Yes, the Star Trek food synthesizer will be a reality by the end of this century, and much, much more that we cannot even yet imagine!**

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