implementation handbook for

'Innovative learning in Ethiopian primary schools'

part I – the concept

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1 Executive summary

"The best way to predict the future is to invent it"

Alan Kay

The following is a frame work for an implementation plan for 'Innovative learning in Ethiopian primary schools' based on a modern and innovative ICT instruments: a laptop for children.

The idea is to launch the project in Ethiopia and to deploy fifty-thousand laptops in Ethiopia within a year, with emphasis on rural, remote and the poorest areas in 2008. These fifty-thousand are the first step and a test of concept. The vision though is to provide all school children with notebooks.

Even though the concept uses as a concrete example of the olpc notebook, it will work with any other device that fulfils the requirements for 'Innovative learning in Ethiopian primary schools'.

A detailed action plan is being provided in parallel with this document.

2 The vision for Ethiopia

In January 2005 the MIT Media Lab launched a new research initiative to develop a $100 laptop—a technology that could revolutionize how children are educated.

The overall vision for Ethiopia is to provide all 14 Mio. students in Ethiopian primary schools with notebooks. Provided that the total costs of implementation per child will be around 150 $ in the near future, the overall needed budget will be roughly 2.1 Billion USD. The launch phase with roughly 50.000 notebooks will establish the necessary service infrastructure (capacity building) for the next phases.

"One laptop per child" is a concept. It is an education project, not a laptop project. It can be implemented in more than one way, by no means limited to the embodiment of the olpc non-profit association's so-called "$100 Laptop."

olpc is possible today because of technology that permits to produce a $100 laptop (today 188$, ~100$ in 2009). But the concept has a long history, dating back to Seymour Papert's original educational theories (1969 and thereafter), repeatedly borne out by experience, as well as the earliest experiences with kids and computers, more than a quarter-century ago, when first Apple computers were introduced to the school children of Senegal.

The argument for one notebook per child in Ethiopia is simple: many children—especially those in rural parts of developing countries—have so little access to school—in some cases just a tree—that building schools and training teachers is one way to alleviate the situation. While such building programs and teacher education are necessary, another and parallel method is to leverage Ethiopia's children themselves by engaging them more directly in their own learning. It may sound implausible to equip the poorest children with connected laptops when rich children may not have them, but it is not. Laptops can be affordable and children in Ethiopia are more capable than they are given credit for.

Technologies like the compass, paper, and printing changed the world. Today there is the opportunity for Ethiopia to revolutionize knowledge once more, by participating in a basic use of digital technology that will empower Ethiopia's school children to explore the most distant places and to access knowledge on an unprecedented scale.

Throughout the world, computing and communications technologies are sparking a new entrepreneurial spirit, the creation of innovative products and services, and increased productivity. The importance of a well-educated, creative citizenry has never been greater.

Most people see a natural connection between computers and education. Computers enable us to transmit, access, represent, and manipulate information in many new ways. But they can do much more than that. They can move beyond static information-centric views of computing and learning by taking full advantage of new computational technologies. These will enable Ethiopian students and their Ethiopian teachers to become better learners and thinkers.

2.1 The Five Ethiopian Principles

The Ethiopian government formulated five principles to be considered in this concept for Ethiopia which will be reflected in the implementation phase. However, to some extend it has to be considered that some principles may are in conflict with each other.

2.1.1 eBook

ebooks are nowadays available around the world. However, the objective is not to increase the quantity of eBooks but the quality and accessibility of customized content. It has to be considered that printing costs for paper textbooks are high. eBooks need no printing costs, but the real advantage is that eBooks can be easily distributed and updated. In the Ethiopian context it also means that books are made available where they were not available before. The official Ethiopian textbooks will be obtainable as eBooks. After a quality check additional eBooks will accompany the curriculum.

2.1.2 eLibrary

The essential part of education to teach children is content. All educational material available in digital format that is going to be used within this project in Ethiopia will be made accessible in an eLibrary. The eLibrary will not only contain the Ethiopian official textbooks, but also additional textbooks as second sources as well as eLearning content for children. Other digital content such as additional software for laptops be stored in the same filing system. The eLibrary will be made available in a master eLibrary out of which regional or local copies can be replicated.

2.1.3 Direct broadcast

The implementation of the project will use as much as possible the existing infrastructure in Ethiopia. It is for example possible to use the Woreda.Net during night to update the school servers. However, the declared objective is to include the school.net infrastructure. A possible usage of the "school.net" infrastructure within the project must be carefully examined and implications and/or requirements to do so must be identified. Possible fields to be explored are:

- Usage of the school.net infrastructure to broadcast existing learning material directly on the notebook (streaming)
- Usage of the plasma screens as notebook-projectors for the teachers to demonstrate tasks visible for all students on a wall or a screen
- Broadcast videos on the plasma screens for
  - Teachers training on notebooks
  - Showing how to re-configure/maintaine the laptop for
    - teachers
    - local enterprises
    - students

According to olpc, videos showing how to re-configuring the laptop will be available.

2.1.4 Interactive Learning

Using technology within the learning and teaching process cannot improve learning per se. Learning is a basic cognitive process, which has to be carried out by the students themselves. This implies that learning is an active process from a learner's perspective. Knowledge and understanding is constructed by the student. Not transmitting information, but also engaging students in authentic tasks (action oriented approach) leads to success. The relationship between interaction and learning can be summarized as the following:

- students´ achievement level depends on what they already know (previous knowledge)
- the mechanism that delivers knowledge should be an interaction
- the goal of learning is problem solving and interactive.

Following this approach, interactive learning will be the driving idea for the educational concept in Ethiopia.

2.1.5 Innovative Learning

The nature of work in a globalized work environment requires future Ethiopian employees to perform increasingly complex occupational tasks. To cope with challenges, students or future employees have to be enabled to act in a flexible manner, solve problems, learn and perform independently and co-operate with others. It is becoming increasing important to acquire occupational action-oriented competence. This innovative learning concept is the so called action oriented learning approach. Students graduating through this approach are expected to have acquired not only skills and knowledge obtained from qualifications, unit standards and curricula. But they also have key competences, such as problem solving techniques, communication skills and the ability to work in teams. One of the most important factors determining the success or failure of innovative action oriented learning is a change in the role of the teacher. In this approach the teacher has still the most important role in planning and structuring the learning process around tasks, problems and questions and he still needs to be expert. He guides the student and enables the students to discover things on their own (as far as this is meaningful).

2.2 *The Five Enablers*

2.2.1 Child ownership

Each Ethiopian child should own his or her own machine and view it not as government property, but as a personal medium, cherished like a bicycle. The child is more confident, has greater self-esteem, and is more entrepreneurial than children without this tool. The laptop will belong to the child student.

A connected laptop is more than a tool. It is a new human environment of a digital kind. The olpc laptop is created at a very low cost, is robust and powerful, beautiful and friendly. It has been designed explicitly for children of the elementary classes, the first one of its kind. The ownership of the laptop is a basic right of the child and is coupled with new duties and responsibilities, such as protecting, caring and sharing this valuable equipment.

2.2.2 Low ages

The laptop is designed for the use of children of ages 6 to 12, covering the years of the elementary school but nothing precludes its use earlier or later in life. Children don't need to write or read in order to play with the laptop and it is known that playing is the basis of human learning. Moreover those digital activities will help the acquisition of the writing and reading skills. The key asset is the free use of the laptop at home, where the child will increase significantly the time of practice normally available at the standard computer lab in the school.

2.2.3 Saturation

The concept is with elementary education in the developing countries. In order to attain this objective one need to reach a "digital saturation" in a given population. The key point is to choose the best scale in each circumstance. It can be a whole country, a region, a municipality or a village, where every child will own a laptop. As with vaccination a digital saturation implies the continuous intervention on the successive cohorts at the proper ages. The whole community will become responsible of the program and the children will receive support of many institutions, individuals and groups of this community. Because of the connectivity inherent to olpc these different communities will grow together and expand in many directions, in time and space. They will become solid and robust, because they are saturated, without holes or partitions. A healthy education is a vaccination, it reaches everybody and protects from ignorance and intolerance

2.2.4 Connection

The laptop has been designed to provide the most engaging wireless network available. The laptops are connected to each other, even when they are off. If one laptop is connected to the Internet, the others will follow to the web. The children in the neighborhood are thus permanently connected to chat, share information on the web, gather by videoconference, make music together, edit texts, read e-books and enjoy the use of collaborative games on line. The battery of the laptop can work for many hours and it can be charged in special gang chargers in the school or by mechanical or solar power. The unique laptop display allows the use of the laptop under a bright sun, enabling the user to work outside the classroom or home, in the wild as well as in any public open place. The connectivity will be as ubiquitous as the formal or informal learning environment permits. A new kind of school is proposed, an "expanded school" which grows well beyond the walls of the classroom. And last but not least this connectivity ensures a dialogue among generations, nations and cultures. Every language will be spoken in the network.

2.2.5 Free and Open Source

The child with an laptop is not just a passive consumer of knowledge, but an active participant in a learning community. As the children grow and pursue new ideas, the software, content, resources and tools should be able to grow with them. The global nature of the project demands that growth be driven locally, in large part by the children themselves. Each child with an laptop can leverage the learning of every other child. They teach each other, share ideas, and through the social nature of the interface, support each other's intellectual growth. Children are learners and teachers. A world of great software and content will be used to make this project succeed both open and closed. The children need to be able to choose from all of it. In the context of learning where knowledge must be appropriated in order to be used, it is most appropriate for knowledge to be free. Further, every child has something to contribute; a free and open framework is needed that supports and encourages the very basic human need to express.

3 Project scope

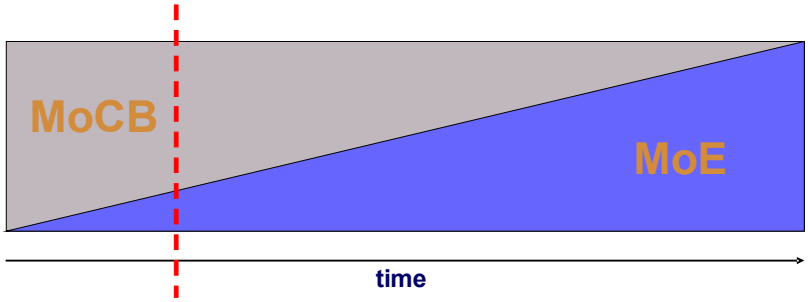
3.1 Capacity Building

Before starting a capacity building process anywhere, it must be ensured that three prerequisites for change are given:

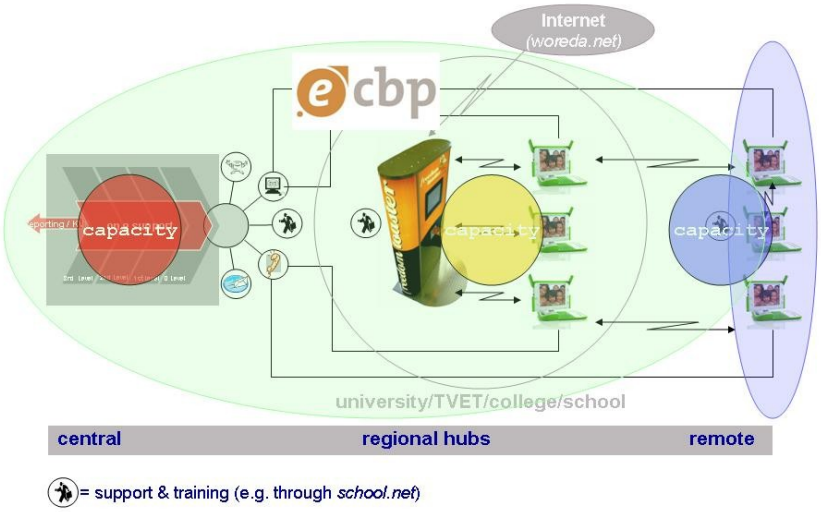
- Need: the need for capacity building has been identified and is recognised by the majority of people affected

- Readiness: the persons involved are ready and open for change
- Ability: the individuals and the organisational structures affected are able to implement changes

The concept is an education project in its core. However, different phases in the implementation have to be considered to guarantee the success of the project.



In the first phase the project in Ethiopia is much more of a capacity building concept for basic education and the ICT sector, since the critical success factor is the ability to support, maintain and run the initiative. Once the capacity building component is established and the service infrastructure is in place the initiative will be a pure educational concept.



The capacity building takes place on 3 different levels (as shown in the graphic):

3.1.1 Central Level

On **the central level** a competence center for the management team of the project and the support & maintenance team will be established. The support & maintenance team on this level will be responsible for providing 3. level support as well as stearing controlling and

training the 1. and 2. level on the regional and remote level. The capacity to be build is focussing on the management team for all kind of organisational issues as well as on the support team which will be trained by experts to the highest reachable niveau. It is possible to start this competence center under a MoCB umbrella and to later pass on the facility to a private sector company.

3.1.2 Regional Level

On **the regional level** the existing ressources that have been developed through eLearning and Open Source workshops by on.e/ecbp will be integrated into the service infrastructure. This is referring to eLearning and Open Source capacities that have been built on that level. The HW maintenance will also be provided on the regional level, since the embedded universities (or TVET centers) will act as a regional warehouse for spare parts. More over the 2. Level support includes the distribution of content into the remote areas where these remote areas dont have independant internet acces. The distribution can be provided through "content outlets" such as the open toaster (developed by on.e) or can be based on individual situations (e.g. even up to manual USB Stick transport).

3.1.3 Remote Level

On **the remote level** only the 1. level support will be provided. There are three different forms of 1. level support:

- the one being conducted by the children themselves (e.g. the back light bulbs can be exchanged by a kid just with a little screwdriver)
- the one being offered by local individuals or micro enterprises such as the local radio repair shop. A training to local individuals or micro enterprises is part of this concept
- the one being offered by the appointed "laptop" teachers; teachers that have been trained to give basic support and help including the access to content (textbooks etc.)

The capacity development on all 3 levels is essential and critical to the whole project and -on the other side- is the entry ticket to roll out, implement and run much more laptops in Ethiopia than "just" 50.000.

3.2 The educational concept

3.2.1 Constructivism & Learning Learning

Constructivism

Learning is an active process. Instruction by the teachers is one important hing, but the teaching and learning can improve if you add something: children who learn by doing and making. Children/ students explore and discover. Constructionist learning involves students drawing their own conclusions through creative experimentation and the making of social objects. The teacher takes on an additional role which is different to a pure instructionist position. Teaching "at" students is added by assisting them to understand—and help one another to understand—problems in a hands-on way.

Many educators outside Ethiopia have experience using computer technology to make good schools even better. They are also familiar with project-based learning, and know how to provide their students with richer and easier access to information by using computer networks to create human networks. This proposal draws on such experiences but does more than merely replicate these experiences on a mass scale. Transforming an entire educational system poses challenges that go beyond those met in improving an individual school.

Since the beginning of constructivism there has been a fight between instructivism and constructivism, but in reality there is no need to choose. They both have their place. Learning through exploration is wonderful, but mastery of a time-honored tradition of study, and knowing that you have met a standard of learning, these are also very powerful and common motivations for people to learn.

Ethiopian students using a notebook should not be cut off from that opportunity simply because they do not have a teacher who knows about different teaching methods and how to use it. There are subjects such as chemistry that do not lend themselves well to unsupervised exploration. Learning chemistry simply through exploration could be downright deadly. In algebra f.e. students generally need to see many, many demonstrations of a skill, and get immediate feedback on their mistakes to be able to learn. For these kinds of subjects, learning and teaching need to be interactive. Much of what a traditional Algebra teacher does: demonstrate problems, give feedback on student work, and construct assessment materials so students will know when they've mastered a skill; all these things can be as well delivered through or added through an interactive tool. In fact, the use of an interactive tool can eliminate one thing that people find very frustrating about traditional classroom instruction: There is no busy-work for fast-learning Ethiopian students, and slower-moving Ethiopian students aren't left in the dust because the class must move at a given pace.

Learning learning

Learning is the ultimate goal. Learning about things that are personally meaningful while reconstructing knowledge to get new knowledge — especially where children realize that they had to extend themselves beyond what they believed they were capable of doing—is both natural and liberating. Ethiopian Children need to learn learning, which is primarily acquired through teachers who enable the passion that comes from access, the ability to make things, to communicate and to express. Learn to learn on the students`side requires specific teachers` skills competences that most Ethiopian teachers are not used to.

It goes without saying that Internet access and tools for expression (text, music, video, graphics) are the contemporary "toys" for learning. Using and learning with the Internet also includes the need for media competency on the students` side, which always has been a school issue f.e. on using and learning with newspapers. More or less every child of any means in the developed world has access to a computer at home and usually his or her own, with music, DVD, plus interactive and rich media to do anything from learning languages to play games. Making these same resources available to Ethiopian children, who do not have such access, has seemed ridiculously daunting, but is no longer.

This project does not focus on computer literacy, as that is a by-product of the fluency children will gain through use of the laptop for learning. Ethiopian children—especially young children—do not need to learn about IT and certainly do not need to be fluent users of WORD, EXCEL and POWERPOINT— they are not office workers. However, picking up these skills, having grown up with a laptop, will be readily accomplished.
The intransigence of the problems of formal education in the face of conventional solutions, combined with pervasive poverty and the need for high-quality lifelong learning for inclusion in the global knowledge-based economy, warrants new thinking. The same digital technology that has enabled an unparalleled growth of knowledge, when combined with new methodologies for learning and teaching, can unleash the latent learning potential of the children of Ethiopia.

Ethiopian children lack opportunity, not capacity for learning. By providing laptops to every child without cost to the child, Ethiopia could bring the poor child the same opportunities for learning that wealthy families bring to their children.

The answer is to provide Ethiopian teachers and students with a laptop—a full-powered and portable computer with a built-in wireless connection that can be used at school, at home, and practically anywhere a child might go. Quantitatively this makes possible more high-quality learning than can be achieved in the hours spent at school. But the real gain is qualitative: the personal laptop removes the barriers that separate learning from living, school

from family and society. As students incorporate the laptop into all parts of their lives, the machine embodies the new Ethiopian culture and fosters its growth within the individual.

3.2.2 Content

Most developing countries use an instructivist model for education. In this model, teachers teach, using textbooks, towards a set curriculum that students are eventually tested against. While a commonly accepted model, and arguably a very useful model where the goal is to bring the greatest percentage of the population up to a consistent level of education, it presents a number of challenges. The first may be in the sheer requirement of material; if a teacher is going to teach to a test, and a student be judged on their ability to pass a test over a set curricula, each student must have fair and equal access to the learning material.

ICT technologies, such as the olpc initiative, have much to offer in this regard. Content that is digitized can be both distributed at lower cost than printed editions, as well as more easily revised to ensure local relevance. ICTs address important points in improving education. First, they deliver traditional educational material to the student (i.e. e-textbooks which can be read as easily as a regular textbook). Secondly, they allow students to explore a given subject in far greater detail: for example with supplementary materials that can be accessed through links in the actual e-textbook. This additional content would be in many different forms – multimedia, online encyclopedias, dictionaries, games, exam banks and experiment simulation, to name but a few.

Moreover, this type of modular content allows for school systems to ensure that children are able to learn a host of new skills, which would not otherwise be possible in a "traditional" classroom setting. For example, teaching entrepreneurial skills may be viewed as a critical element in developing productive citizens. By creating interactive games and other simulation-based activities, ICT tools are able to efficiently realize such objectives. A further benefit of this is that the activities and simulations are scalable through grade levels, and allow students to move according to their own pace.

3.2.3 Beyond school

A nationwide roll out of personal machines can capture many more hours per day than school itself, not to mention night time, weekends and holidays. This will mobilize Ethiopian children. In addition it has significant spill-over effect on the entire family where a child has a laptop.

Of the many values of scale, the foremost is the child as teacher. Peer-to-peer learning is one of the best ways to leverage children. The reach of such collaboration can go far beyond national borders and, in the longer term, lead to the bigger goals of world peace and

understanding. Any parent whose child has a laptop at home has almost undoubtedly asked that child for help. What then follows is a change in one's relationship with the child, with more elements of friendship and (on the child's part) self-esteem. This by no means destroys the parent-child relationship. On the contrary, it enhances it. A bond to learning is formed between the child and parent at home. Current pilot projects have shown unequivocally that parents become more engaged in their child's learning and, very often, learn to use the laptops themselves. The role of the child in society changes; it is a more productive role. The child is not the object of change but the agent of change.

3.2.4 Prove of concept

The concepts underpinning the project have already taken root around the globe. One of the earliest programs was started in 1989 when the Methodist Ladies College in Melbourne, Australia, began requiring all incoming students from the fifth to twelfth grades to arrive with their own portable Toshiba laptops. Since then, schools in numerous countries have followed the Methodist Ladies College's lead. For example, Costa Rica's program for bringing computers into education, the first—and still most-widely-praised program on a national level—is based on a design by Seymour Papert; implemented in collaboration with a team from the Media Lab. Other initiatives range from the modest—a small but so-far promising program involving 50 children in two remote Cambodian villages—to the ambitious, such as the U.S. State of Maine where the State legislature has mandated that all middle- and high-school students be issued their own permanent laptops. An estimated 1000 U.S. school districts have followed Maine's example. There are two similar programs currently underway in France, including one in Marseilles, the nation's second-largest city, but a economically -depressed town with enormous ethnic and cultural diversity. Besides olpc there is international experience with using laptops in the classroom. F.e. there has been a success story of laptop classes in Germany supported by Bertelsmann Foundation.

It is too early to assess the full impact in detail, but the most extensive study to date, a four-year investigation of 50 schools across the U.S. conducted by Saul Rockman, a widely-respected educational consultant, ratifies Seymour Papert's constructionist theories that underpin the philosophy. Key findings are:

Learning environments are transformed:

- Educators involved in laptop programs … promote collaborative learning and … provide individualized instruction
- … students and teachers move around more. Instead of staying put to do seatwork, students gather to work on projects
- … (this) frees teachers to roam about the room helping those who have problems or need remediation

- … learning in laptop classrooms is often more self-directed.

Assessment techniques change:

- Teachers in laptop classrooms are more willing to assign presentations and multimedia products to students, and score them using customized, project-driven rubrics and even self-assessments.

Students are highly engaged:

- Like teachers, students also show improved technology skills and sophistication.
- Productivity increases
- Students develop better organizational skills because they now need them to keep track of what's on their computer and to accomplish complex project work in a timely manner
- Attitudes toward writing improve
- 76% of students said they enjoy writing more on the laptops than on paper
- 80% indicated laptops make it easier to rewrite and revise their writing
- 73% said they earn better grades for laptop work

The data demonstrate shifts in not only students' writing attitudes, but also in their practices. These are changes also observed in language arts teachers' writing instruction strategies, and in the attitudes and practices of other content area teachers. "It absolutely begins to transform the high school," said one school administrator in Florida:

"It's the single most dramatic thing I've seen affect the classroom-in a very positive way."

Other studies exist that show a positive relationship between computer use and learning:
- National Center for Educational Statistics (2001)
- BECTA (Cox 2003; Harrison, et al., 2003).

However, often single studies—even those that are well-designed—are constrained by the particular context or situation in which they were conducted and this limits the generalizability of their conclusions. So it is fair to say that there are studies too that couldn't show a relationship between computer availability or use and student test scores (Banks, Cresswell, and Ainley in Australia (2003), Dynarski, et al., in the U.S. (2007)).

3.3 Economics & the ICT concept

3.3.1 Economics

The olpc laptop is a fully powered, general purpose machine sized for children and adolescents, running Linux, with wireless connectivity.

From a recent U.S. survey measuring students' attitudes about writing Global implementation of olpc clearly is infeasible when the average cost of low-end laptops is above $800, in spite of a few new proposals at $300. Even that is too high. When the price of a full-feature laptop approaches $100 (ca. 2009/2010), olpc makes compelling economic sense for a large-scale experiment, in part because, amortized over five years, it comes closer to the cost of textbooks.

olpc reduces costs in five major ways:

1) Reducing to nearly zero the usual cost of sales, marketing, distribution, and profit. Together, these typically account for over 50 percent of a laptop's price
2) Innovation in the machine's display. The display accounts for 50 percent or more of the machine's remaining cost. olpc has devised several strategies for reducing those costs to about $37 per machine
3) Putting the laptops on an operational diet, so to speak. This saves up to 75 percent of the residual expense by deploying a scaled-down processor and needing less memory, using a significantly lighter-weight operating system—a "skinny Linux"
4) Designing and building olpc machines to be rugged and durable, thus reducing the annualized cost of using them. The implementation concept will also engage the children to do most of the maintenance and repair
5) Moving in entirety to an open-source model for software: OS and applications

olpc commits to holding and driving down costs in the future, as well; the enormous potential volumes of these machines should enable unprecedented scale economies in manufacture.

olpc is a non-profit company, meaning that its mission of providing high-quality laptops at the lowest-possible price will not conflict with the more typical, profit-making responsibility of increasing shareholder value.

olpc machines will be less prone to theft, because they will not be available on the retail market. Anybody seen using one had better be a student or a teacher. In time, implementation of olpc also will considerably reduce the need to purchase expensive and

bulky textbooks. More immediately, the laptop can address persistent shortages in classroom and library supplies like paper, colored pens, and books.

3.3.2 The hardware

The first prototype, styled by Design Continuum, was unveiled at WSIS, Tunisia by UN Secretary-General Kofi Annan and Nicholas Negroponte.

The hardware specification (see annex) for the first generation machine is pretty much set. There are many aspects in which this design is truly ground breaking and make this the first of a new class of systems, unlike any other "laptop" in the world.

Children in Ethiopia need more—not fewer—features than high-end laptops. The laptop is first and foremost, rugged, followed by light, small, and attractive. Its design includes three special features not found on current laptops and that makes it superior to other "cheap" and less-powerful machines. Notably, Ethiopian Children need three things unique to their condition:

- Low power consumption
- Sunlight readability
- Mesh network / automatic connectivity

3.3.2.1 Power consumption

Low power is key. Today's laptops run at between 30 and 40 watts. Ethiopia's olpc will run at an average of 2 watts. The reason are

1) long battery life
2) the option to use human power. Most Ethiopian children do not have electricity at home. Therefore, a laptop needs to run on both human power and long-life batteries. Human power, whether cranking or other gestures, must run a laptop at least 1-to-10: one minute of cranking provides ten minutes of use. In the case of batteries, a 10-hour life is need. Laptops cannot be plugged in at desks in classrooms. Even the richest schools in Ethiopia do not provide power to each desk in any case.
3) The option to use solar power. Solar modules can be used to charge the battery in a sustainable and reliable way. With a 5 Wp solar modul it is possible to charge the battery in 2-4 hours. This way children laptops are provided with sufficient energy. An important side effect: The solar module can be also used to charge mobiles or other batteries too.

3.3.2.2 Sunlight-readable displays

13 months of sunshine in Ethiopia: Sunlight-readable displays are important for outdoor use as well as power conservation. This should be achieved as an option to traditional backlighting, not as a replacement to it. Both are needed. Furthermore, during night-time use, the laptop itself needs to be the light source for the surrounding area. The dual-mode display allows the laptop to be used outdoors, in full sunlight. In fact, the brighter the sun, the better the image. That is one mode. The second mode is the more traditional back-lit method common to DVD players and the like.

3.3.2.3 Mesh network

Connectivity in Ethiopia cannot assume DSL, WiFi hotspots, or the like. Instead, the laptops collectively have to make a network automatically, without child or teacher intervention.

This so called mesh network is included for three very different reasons:

1) The first is to allow hundreds of children to share one network as long as a child is within 300 meters of another child
2) The second is to have maximum peer-to-peer communications among children, to the extreme of sharing memory and serving as peripherals for each other.
3) The third is that the laptops in a mesh network can use a single satellite connection be shared among schools and villages

Roughly 500 children should be able to share a single point of back haul to the Internet. While this may be modest bandwidth, among themselves and with a school server they must have very broadband connections.

Laptops are communication devices. Current laptop design has been mostly motivated and influenced by use in the developed world and, to a lesser degree, by the business user. The laptop's intended users are different and that has to be reflected in all aspects of the laptop's design. When it comes to networking, the design's main influencing principles are that:

- Learning stems as much from communicating and interacting as it does from teaching
- No infrastructure should be taken for granted in the developing world
- Starting from the above, one easily concludes that the best possible communications solution for the laptop is a WiFi radio. This doesn't present any deviation from mainstream commercial laptops and the laptop's 802.11g compliant chipset supports all the latest industry standards.

The similarities end there though. One of the most important characteristics of the laptop is that it supports "mesh" functionality via its 802.11 radio. This means that the laptops automatically (and transparently to their users) form connections between them and cooperatively relay packets for each other. This allows their users to be able to communicate as if they were all connected to the same 802.11 access point.

The mesh functionality is implemented mostly at Layer-2 eliminating the need for higher layer protocol modifications. The laptop uses a System-on-a-Chip (SoC) WiFi radio (Marvel 88W8388) with its own CPU (ARM9 core) and memory. This allows for all necessary frame-forwarding functionality to be implemented on the radio itself, so that the mesh can function independently of the main CPU (only needing ~500mW of power).

Another significant difference is the antenna design of the laptop. Instead of the standard ~ –1dBi PIFA designs present on most laptops these days, olpc uses dual 2+ dBi omni-directional rotating diversity antennas that allow reliable operation at distances of 300m between laptops (@2mbps).

The laptop will be supporting the upcoming 802.11s standard (as it emerges) with an emphasis on reliability rather than performance. The laptop achieves that employing a variety of techniques (conservative use of signaling speeds, advanced link quality metrics, robust optimized on-demand routing algorithms).

Given that the mesh is implemented with single half duplex radios on each node, the end to end throughput between any two nodes in the mesh is directly related to the number of hops (intermediate relay nodes) between them. 300Kbps of throughput should be expected in "village"-sized areas (1km). For larger areas, the design allows for graceful degradation as the number of hops increases so that that a minimum level of performance (30–50Kbps) is maintained. This can happen by taking advantage of "pipelining" effects that are possible in multi-hop paths. Autoconfiguration, resource and service discovery, IPv6 and limited multicasting will be supported over the mesh. Applications in the initial release will include instant messaging, walkie-talkie voice, file and web sharing. It should be emphasized that all these applications will have to operate in a peer to peer (server-less) fashion.

Although the laptop's mesh capability addresses last mile issues, it will have to be combined with backbone Internet connectivity which is, in most cases, very expensive in the developing world. That mandates for whatever backbone connectivity is available to be efficiently shared among as many children as possible. In remote areas with little or no infrastructure, Satellite internet connections as well as packet cellular telephony connections will provide

connectivity to the laptop-equipped children. Both technologies have severe bandwidth limitations.

In order to make for the best possible use of that limited bandwidth, the following principles will have to be applied:

- Use of peer to peer applications, so that client-server control traffic through the backbone line is minimized
- Empowerment of the children to both create and share content so that, again, traffic stays local
- Putting a low-cost server in every school so that content can be cached locally

3.3.3 The software

This project is committed to the principle of Open Source. Developing software for this machine is very straight forward. olpc is being developed as an open platform and will be distributed with open-source software. There are a number of reasons for making the choice, not the least of which is that paying for software would adversely impact the ability to continuously drive down the cost of the machine. But regardless of these cost considerations, open-source software will be used because this concept wants to enable the children, their teachers, the educational community, and developers serving that community to have the freedom to continually grow with the machine. The success of the project in the face of overwhelming global diversity will only be possible by embracing openness and by providing the laptop's users and developers a profound level of freedom.

As the children grow and pursue new ideas, the software and the tools should be able to grow with them and provide a gateway to other technology. Thus one of the central tenets is that all aspects of the machine be open to the children, so that they own it in every respect.

To achieve these and other practical goals the software platform must include open source code and allow modification so that developers, the Ethiopian government, and the children who use the laptop can change the software to fit an inconceivable and inconceivably diverse set of needs. Those provided by olpc are:

- a self-hosting development platform
- adhere to and advocate for open standards
- In order to foster an international community of support around the project will provide tools for the developer community:
    - Upstream hosting for olpc-related projects
    - Discussion forums
    - Developer conferences

- Etc.

- encourage localization and internationalization work to be done "upstream" so that the entire development community benefits
- encourage other countries themselves to grow the local infrastructure and culture of support (both in order for the project to scale and that they—the countries—have determinism over the machines).

The project is dependent upon the open-source community and therefore must be respectful of that community. That said, one goal is to get the education community to learn from the open-source community about the culture of create, modify, and share. Engaging the Ethiopian education community in the rich process of learning associated with open-source development and debugging will be transformative.

While the olpc initiative itself is working with the open-source community, it is putting no restrictions upon third parties to work with proprietary software. The platform is open to anyone who would like to develop for it.