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Demystifying Cloud Computing for Higher Education

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Overview

The concept of a site as we know it will change.
—Ben Rushlo, Keynote Systems

A thorough review of the burgeoning (or perhaps billowing!) literature on cloud computing leaves one simultaneously excited and confused. Excitement and confusion are common companions for information technologists who are confronted regularly with things that are new, things that promise to transform, and things with ambiguous names! Our review of this early literature does conclude that, despite the hype, cloud computing is different and is important.

This ECAR research bulletin is the first in a series of bulletins devoted to cloud computing in higher education. It summarizes insights and a framework for thinking about cloud computing, and it touches on potential emergent roles for public and private clouds. The findings draw from interviews in the spring of 2009 with industry and university information technology (IT) leaders, a review of current literature, and a synthesis of recent research from the EDUCAUSE Center for Applied Research (ECAR).

Highlights of Cloud Computing

The literature on cloud computing suffers from hype and divergent definitions and viewpoints. One report by McKinsey & Company uncovered 22 distinct definitions of cloud computing. For this research bulletin, we will use the Gartner, Inc., definition of cloud computing as "a style of computing where massively scaleable IT-enabled capabilities are delivered 'as a service' to external customers using Internet technologies."[1] McKinsey & Company presents a typology of software-as-a-service (SaaS) that elaborates the Gartner definition and is characterized by:

- **Delivery Platforms**
  - *Managed hosting*—contracting with hosting providers to host or manage an infrastructure (for example, IBM, OpSource)
  - *Cloud computing*—using an on-demand cloud-based infrastructure to deploy an infrastructure or applications (for example, Amazon Elastic Cloud)
- **Development Platforms**
  - *Cloud computing*—using an on-demand cloud-based development environment to provide a general purpose programming language (for example, Bungee Labs, Coghead)
- **Application-Led Platforms**
  - *SaaS applications*—using platforms of popular SaaS applications to develop and deploy application (for example, Salesforce.com, NetSuite, Cisco-WebEx)[2]

In addition to being ill-defined, cloud computing is emergent. In its 2008 hype cycle, Gartner characterizes cloud computing as a technology that is moving up toward the peak of inflated expectations. That said, Gartner predicts that by 2011, early technology adopters "will forgo capital expenditures and instead purchase 40% of their IT infrastructure as a service."[3] Gartner analyst Daryl Plummer and his colleagues go on to conclude that "the perception of infrastructure as something that must be bought, housed, and managed has changed. Companies are now seriously considering alternatives that treat the infrastructure as a service rather than an asset and that care less where the infrastructure is located and who manages it."

The analyst literature generally agrees with the Gartner assessment above that cloud computing will achieve mainstream adoption in a 2–5 year time frame. Again, this estimate reflects the generally inclusive definitions of cloud computing. The definitions often include things like basic web services, service-oriented business applications, SaaS, virtualization, and even managed hosting—technologies that are themselves at differing levels of maturity. Already by 2008, among commercial firms (N = 857), 35% of IT software budgets (about 10% of total IT expenditures) are spent on subscription, on-demand, transaction-based, advertisement-funded, or other nontraditional forms of software acquisition.[4] Finally, the literature asserts that cloud computing is different and it is important.

What Is Different About the Cloud?

Information technologists—particularly those in higher education—are skeptical about hype. After all, haven't we all seen, heard of, tried, used, or continued to use service bureaus, application hosts, grids, and other sourcing techniques? So what is different about the cloud?

The first key difference is technical: the maturity of standards throughout the stack, the widespread availability of high-performance network capacity, and emergence and diffusion of virtualization technologies are combining to enrich the sourcing options at our disposal. Markets are different. Consumers are different. And the economic climate has changed.

The generation raised on broadband connections, Google search, and a Facebook community is likely to embrace the idea of cloud-based services in their enterprise roles, just as they embrace them in their private lives. Such users, who are driving the rising sales of netbooks, are likely to fuel the drive toward lower-cost and lightweight computing clients and web-delivered, open-source operating systems and applications. According to Gartner, "The consumerization of IT is an ongoing process that further defines the reality that users are making consumer-oriented decisions before [they make] IT department-oriented decisions."[5] The failure of the enterprise IT organization to socialize this insight might lead to the evolution of "accidental" IT architectures and to a "struggle to shut down user-introduced technologies or to accommodate them in a secure and predictable fashion."[6] The consumerization of IT along with the emergence of SaaS and other web-based services options will drive the movement of enterprise services both "above" the campus in the form of high-end resources able to replace traditional premises-based services, and "below" the campus in a multitude of commodity tools and environments directly available to users.

At the same time, the current financial crisis and the focus on managing IT costs and return on investment are driving commercial enterprises to move swiftly. The top-two trends identified by 56% of 857 respondents to McKinsey & Company's 2008 enterprise software survey were SaaS and web services/SOA. Budget cuts in higher education are likely to accelerate explorations of sourcing alternatives.

Finally, recognizing these technical, generational-consumer, and enterprise economic trends, developer communities and system integrators are shifting away from established software vendors, and the established vendors are working to "cloud-enable" their products.[7]

Big Switches and Permeable Walls

McKinsey & Company suggests that "using clouds for computing tasks promises a revolution in IT similar to the birth of the web and e-commerce."[8] Burton Group concludes that "IT is finally catching up with the Internet by extending the enterprise outside of the traditional data center walls."[9] Writers like Nicholas Carr argue that a so-called "Big Switch" is ahead, wherein a great many infrastructure, application, and support tasks now operated by enterprises will be handled by very-large-scale, highly standardized counterpart activities delivered over the Internet.

The prospect of a maturing cloud of on-demand infrastructure, application, and support services is important as a possible means of

- driving down the capital and total costs of IT in higher education;
- facilitating the transparent matching of IT demand, costs, and funding;
- scaling IT;
- fostering further IT standardization;
- accelerating time to market by reducing IT supply bottlenecks;
- countering or channeling the ad hoc consumerization of enterprise IT services;
- increasing access to scarce IT talent;
- creating a pathway to a five-9s and 24 × 7 × 365 environment;[10]
- enabling the sourcing of cycles and storage powered by renewable energy; and
- increasing interoperability between disjointed technologies between and within institutions.

Commercial enthusiasm for cloud computing tends to cluster around agility, economics, and the size of the in-house IT organization. One interviewee we spoke with drove home the ease of deployment (agility) argument vividly: "If you are Flowers.com and your steady state business is punctuated by massive demand spikes on Valentine's Day, Easter, and Mother's Day, access to public cloud services represents a great opportunity to grow your IT infrastructure quickly during times of peak demand. This use of cloud services solves a very real business problem in a very cost-effective manner."

Public clouds appear to be organized around site factors like those mentioned, and, not surprisingly, massive centers like those operated by Google and Amazon are located close to hydroelectric facilities or other renewable energy sources and exploit tax preferences, facility scale, access to networking, and the like. Public clouds are profit-driven and are most effective with those services that are highly commodified. If an IT service can be offered in a standardized fashion without special regard to end user variations, or to local, state, regional, or even national regulatory differences, then that service can be offered as an undifferentiated commodity service—presumably at a great price. In such a case, the dominant legal principle is likely to be *caveat emptor*—buyer beware—backed by standard contract language shielding the provider from any significant liabilities for process failures or data corruption and loss. Public clouds do offer more highly differentiated services, such as hosting e-mail applications. If, however, such a service either differentiates the institution, or is highly integrated with things that differentiate the institution, the benefits of scale or the capacity to use software as a differentiator may be blunted in a cloud context.

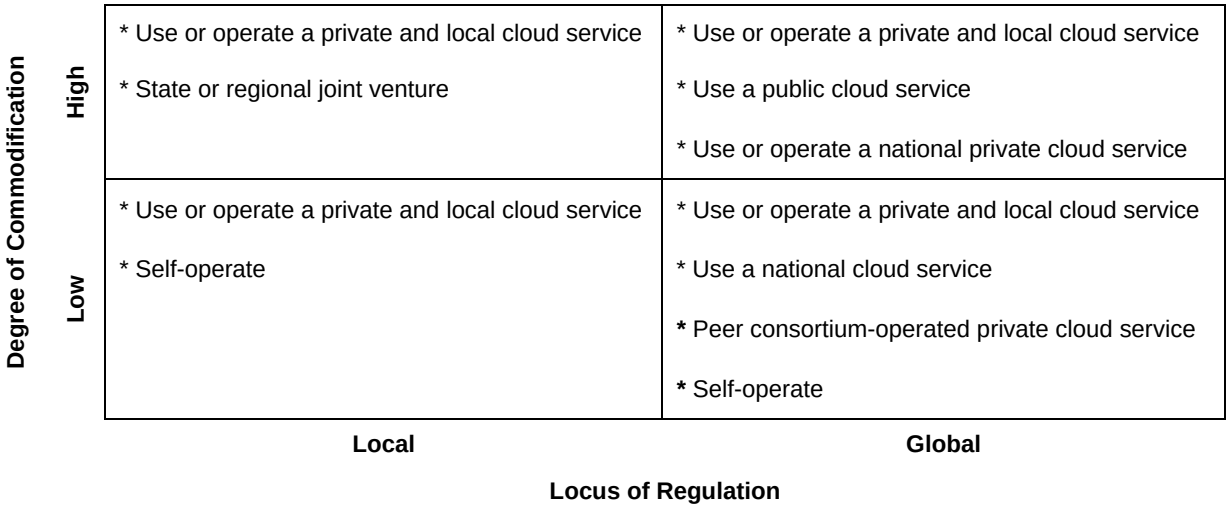
In cases where an IT activity adds unique value or is situated in a unique institutional or industry setting, private clouds are likely to emerge. Private clouds exploit a portion of the potential to cut IT costs by promoting asset consolidation through virtualization. Even more, private clouds make it possible in theory for enterprise IT providers to let go of more complex, risky, idiosyncratic, and value-laden IT activities. Massive organizations such as the U.S. Department of Defense are investing in private cloud technologies and deployments that have the potential to consolidate, integrate, and harmonize disparate IT operations from the Pentagon, military suppliers, military branches (and their academic academies), and so forth.

Thinking systematically about the factors of commodification and the strength and location of regulation and control might help colleges and universities navigate the evolving public and private cloudscape (see Figure 1). In the illustration below, “local” is shorthand for “folks like us” rather than simply “people down the street.” This illustration tries to communicate the idea that computing clouds over the long term will need to cover institutions that are subject to similar regulation and control. For example, all community colleges in California are subject to California law and to the policies of the California Community College System. It might be that a CCCS cloud would make sense. Computing clouds leverage scale economies, while regulatory variation tends to offset or negate scale economies.

“Regional” is used below to describe situations in which a regional service base, or a common regulatory tie, is shared by multiple institutions within a geographic region, e.g., “We serve Nebraskans!” In these instances, organizations such as CENIC, Merit, or NYSERNET might oversee cloud services for disparate institutions that share geographic commonalities.

“Public clouds” are cloud service providers, such as IBM, Amazon, or Google, that take all comers for a given service. “Private clouds” are built to serve organizations tied together by common purposes and needs. Such clouds might be governed by the organizations themselves.

Figure 1. Impact of Regulation and Commodification on Cloud Decisions



The factors in the services sourcing decision are clearly more complex than represented here. That said, a discussion in higher education of these factors is important. Early sourcing decisions in higher education may be moving to public cloud offerings due to the lack of private alternatives and to the advertising-based subsidies some can provide. These factors may skew decision making in ways that will pose challenges downstream.

Finally, it is important to note that many institutions are already sourcing services above campus, if not technically in a cloud computing fashion (see Table 1), though these services are often limited in scope.

Table 1. Forms of Alternative Sourcing Currently in Use (N = 309)

Form	Percentage Adopted
Application software via the Internet (SaaS)	49.8%
Third-party-provided ERP project management	19.1%
Third-party-provided network design	18.8%
Third-party-operated help desk (e.g., call center)	14.2%
Third-party-managed network operations	9.4%
Internet or cloud-based servers	9.1%
Internet or cloud-based storage	7.8%
Primary data center provided by a third party	7.4%
Third-party-provided desktop computing support	7.1%
Internet or cloud-based security applications	4.5%
Internet or cloud-based software development environments	3.6%

Source: Philip J. Goldstein, Alternative IT Sourcing Strategies: From the Campus to the Cloud *(Research Study, Vol. 5) (Boulder, CO: EDUCAUSE Center for Applied Research, 2009).*

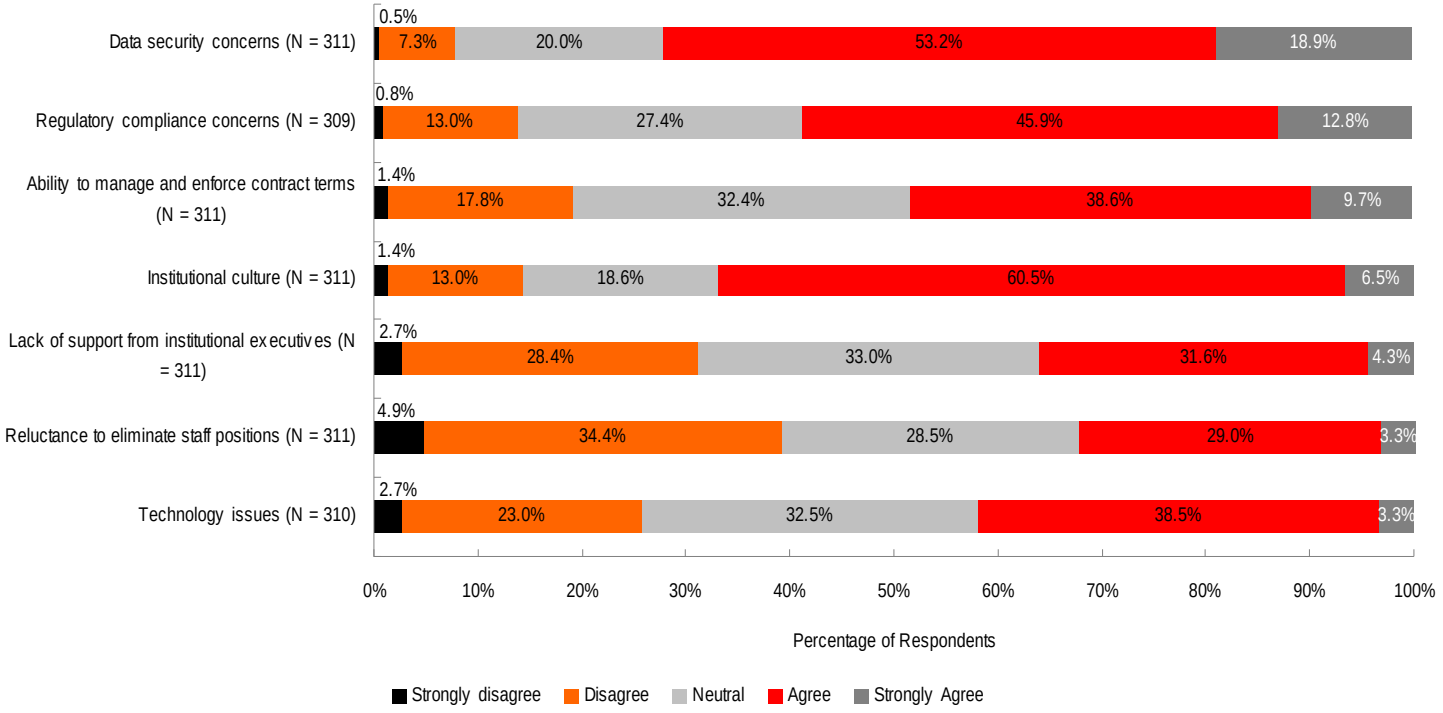
What It Means to Higher Education

The challenges and risks that will constrain higher education's adoption of cloud computing relate to trust, confidence, and surety. As Burton Group analyst Drue Reeves points out, "Building an IT organization's confidence in a solution requires a combination of consistent performance, verifiable results, service guarantees, transparency, and plans for contingencies."[11] Clearly most cloud services do not have the track record on which one can build the necessary trust to shift existing services without either great deliberation or a very compelling benefit. These service and provider attributes only come with time, reputation, and experience. Compounding these challenges, most IT organizations in higher education are not themselves highly skilled in managing risk and service performance *in third parties*. In the commercial sector, lack of confidence in the cloud stems from

- poor or nonexistent service level agreements;
- inadequate risk management;
- ROI justification, management of change orders, and vendor lock-in;
- market immaturity, and
- management issues.

In higher education, the issues tend to be the same, though the magnitude of concern is amplified by the additional burdens of public trust placed on institutions that serve *in loco parentis* for students and that conduct patient care, research on human subjects, and so forth. Among respondents to a November 2008 ECAR survey, two-thirds of those who outsource cited their institutional culture as a real barrier to adopting alternative sourcing approaches. Of those who outsource, nearly three-quarters (72.1%) cited concerns about IT security, and more than half (58.7%) indicated that concerns about regulatory compliance will limit their adoption of these emerging service offerings (see Figure 2). As one participant in our spring 2009 interviews expressed it, "We need to have an honest discussion of the control and privacy issues. State and federal law make these concerns real, but these policy issues can be resolved technically and architecturally. Unless we commit to study these issues, we won't be motivated to move services to the cloud."

Figure 2. Barriers to Alternate Sourcing Options



Source: Drawn from survey data from Philip J. Goldstein, Alternative IT Sourcing Strategies: From the Campus to the Cloud *(Research Study, Vol. 5) (Boulder, CO: EDUCAUSE Center for Applied Research, 2009).*

At this stage in the development of cloud computing, several important conclusions for higher education can be drawn:

1. Cloud computing shows great promise, but that promise is accompanied by tremendous hype. This review of the literature and concurrent widespread discussions with IT leaders suggest that despite the hype, cloud computing is an important development on a par with the shift from mainframe to client-server based computing. As Michael King of IBM put it in our interviews, “We have commoditized hardware and software. The question now is how do you drive down the cost of IT? It is a fundamental shift.”

Notwithstanding the near unanimous belief that cloud computing is an important enabler of a fundamental shift in the organization and economics in enterprise IT, the (non-hyperbolic) literature and the discussion with community leaders also make clear that at present the topic is mired in hype and near-utopian optimism. While a shift to above-campus computing may be inevitable, and while planning and experimentation should begin now, it is clear that the higher education IT community needs guidance and that many pitfalls will be encountered in the road ahead. As Scott Siddall, formerly of Kenyon College, argued, “We need to take a magnifying lens to the cloud. This whole topic needs to be stripped clean of hype.” In addition to needing to see through the hype, members of higher education’s IT community will need to take care to acknowledge than not all clouds are the same. As

Internet2's Doug Van Houweling put it, "Different clouds have different implications for the weather. We have not yet learned enough about these different clouds."

2. Policy and control issues will slow cloud adoption in higher education. Among a great many issues related to adopting a cloud computing approach to delivering services, policy and control issues seem paramount. These issues run the gamut from audit to process management, to IT governance, to regulatory compliance, to IT security, and to the management of and accountability for access management, privacy, e-discovery, and protection of research results. Both the literature and discussions make clear that while the issues are substantial, improved understanding of these risks will shift the preference of many IT owners and regulators over time away from the costs and inconsistency of on-premise IT and toward the auditable and highly professional practices cloud service provides as this market matures.

3. Above-campus services will have real costs, and an honest accounting needs to be done. The people who participated in this discussion believe that public and private cloud services will come to market quickly but that the uptake of these services within higher education will occur relatively more slowly and unevenly. Further, the pace and evenness of adoption will depend on the length and depth of the current economic downturn. Participants also overwhelmingly agreed that the shift to above-campus computing is presently being influenced by subsidies from providers that exploit advertising or other revenue sources. The shift to above-campus services in the long term will need to be based on both a realistic assessment of the limits of alternative funding and a full and honest accounting of the costs of in-house enterprise IT activities. Services provisioned above campus will have a real financial cost, and they will be consumed (or not) in part based on a real comparison of these costs with the full accounting and opportunity costs of self-operation.

4. Different classes of computing activity will move to the cloud at different rates of speed. Discussants distinguished between three classes of computing capabilities: (1) services for campuses that overlap services provided commercially (like e-mail, VoIP telephone); (2) applications that campuses need to run for their institutions (ERP), and (3) research work that exhibits scale economies at the application level. The first area is very likely to grow and perhaps grow quickly. The second area has particularly strong policy, process, and control needs and is therefore likely to shift slowly, if at all. The third area is already highly virtualized (grids, remote instrumentation, supercomputing, etc.) and is likely to become increasingly virtualized.

5. There is a good deal of consensus around which services might be candidates for sourcing above campus. Participants in the discussion of higher education cloud services identified candidate services for delivery above campus. Entries to this list were not evaluated in terms of their degree of difficulty to source off premises. This topic deserves further treatment:

- Business availability/disaster recovery
- Computer labs for students
- Computing cycles

- Cooperative (library) collection development
- Desktop support
- Data storage
- E-mail
- ERP
- Identity services
- IT help desk (Tier 1)
- Telephony

6. Many organizations and firms are exploring becoming providers of cloud services. A number of higher education organizations are engaged in discussions, plans, and actions that might position themselves as cloud service providers. These include large universities and university systems like Carnegie Mellon University, Indiana University, the University of California, North Carolina State University, and others, as well as national organizations such as EDUCAUSE, Internet2, the Kuali Foundation, the Quilt, the CampusEAI Consortium, and regional organizations such as the Regional Optical Networks.

7. New services will move above campuses before older self-operated services. The literature and higher education experts agree that the migration to cloud-based services is likely to occur more rapidly when a service is new or where demand for an existing service is new. Migrating mature services to meet existing demand will lag.

8. If the institution does not create a cloud strategy, it may inherit an "accidental strategy" formed around consumer choice. Consumer adoption of cloud services is creating a situation where the "cloudification" of institutional services will take place with or without institutional leadership. Like Gandhi, CIOs may need to run to catch up to their users if they are to remain IT's leader in the enterprise![12]

Key Questions to Ask

- In what ways is our institution positioned to transition from self-operated to (the appropriate) cloud computing services?
- Are our processes and our data subject to considerable regulation?
- How local (institutional policy, state law or regulation, national) is that regulation?
- How institution-specific is the activity or service we want to consider performing using cloud services?
- How well does our institution tolerate risk?

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Endnotes

1. Gartner, Inc., *Cloud Computing: Defining and Describing an Emerging Phenomenon*, June 17, 2008, 3. IDC defines cloud computing as "consumer and business products, services, and solutions delivered and consumed in real-time over the Internet." That is, "shared services, under virtualized management, accessible over the Internet (by people *and* other services) via Internet standards." See Frank Gens, IDC, "Clouds and Beyond: Positioning for the Next 20 Years in Enterprise IT," presentation delivered, San Jose, CA, March 2009, http://www.slideshare.net/innoforum09/gens.
2. McKinsey & Company, "Enterprise Software Customer Survey, 2008" (Sand Hill Group, 2008), 6, http://www.interop.com/downloads/mckinsey_interop_survey.pdf.
3. Daryl Plummer, et al., *Gartner's Top Predictions for IT Organizations and Users, 2008 and Beyond*, January 8, 2008.
4. McKinsey & Company, *Enterprise Software Customer Survey, 2008*, 4.
5. Plummer, *Gartner's Top Predictions for IT Organizations and Users*, 12.
6. Ibid, 13.
7. Interest in cloud computing has become so widespread that on September 9, 2009, Jim Lehrer devoted nine minutes of the PBS NewsHour to a segment on how cloud computing could transform the Internet. See http://www.pbs.org/newshour/video/module.html?mod=0&pkg=9072009&seg=5.
8. McKinsey & Company, "Clearing the air on cloud computing," discussion document, March 2009, 2, http://uptimeinstitute.org/images/stories/McKinsey_Report_Cloud_Computing/mckinsey_clearing_the%20clouds_final_04142009.ppt.pdf.
9. Drue Reeves, et al., *Cloud Computing: Transforming IT*, Burton Group Cloud Computing In-Depth Research, v1, April 20, 2009, 7, http://www.burtongroup.com/Guest/Cloud/CloudComputingOverview.aspx.
10. Five 9s and 24 × 7 × 365 are measures of IT system availability. Five 9s refers to uptime (of a computer or network) of 99.999% of the time; 24 × 7 × 365 refers to the availability of a system, a network, or a service 24 hours a day, 7 days a week, 365 days per year.
11. Reeves, *Cloud Computing: Transforming IT*, 33.
12. B.G. Verghese describes a famous cartoon by Shankar that shows Gandhi running to catch up with a ragged crowd. The caption says: "There go my people. And I must hurry to follow them. For I am their leader." See http://www.bgverghese.com/YouthCadres.htm.

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