Joseph Bristow,

Cloud systems have become increasingly popular for use by business professionals and scholars. There is a growing call for open access to information and collaboration between institutions as well as flexible storage solutions and cloud providers have stepped in to answer this call. Multiple parties can view and edit content as well as comment on each other's work through the cloud. In addition to streamlining teamwork, cloud systems offer simple and secure storage solutions for growing amounts of born-digital content. By storing digital information in series of blocks, which are then copied and stored at various data centers and accessed through connected networks, these born-digital objects can be viewed by anyone with an internet connection. Beyond its obvious use in businesses that require multiple team members to work on one project, often remotely, libraries and archives are increasingly holding up cloud storage to answer the call for dynamic interaction between institutions and between users and repositories.

For professionals and individuals whose growing collection of digital materials poses a storage issue not only because of the amount of space it takes up on a hard drive, but because of the catastrophic loss that could occur if that hard drive failed, cloud storage is a more secure way of ensuring long term access to those materials.

Dropbox was one of the first businesses to take advantage of cloud technology. At first, Dropbox was simply a way to store information and allow access to this information by multiple users. Following the example of other cloud-based businesses, such as Google Drive, Dropbox now allows users to create and comment on documents on its server. It has recently shifted its brand to cater to independent, creative businesses. Dropbox continues to be one of the most widely used cloud solutions for individuals and businesses. Its interface is simple and easy to use and it offers competitive pricing for impressive storage capabilities.

In many ways, however, Dropbox is falling behind the trend in Cloud Computing. As more and more businesses invest in this technology, competitors are developing increasingly complex and customizable applications. An increasing awareness about security concerns inherent in third party hosting of sensitive data has caused businesses to consider private storage options. This isn't possible for users who don't have unlimited local IT support and a considerable technology budget for building stacked networks onsite. Thus, cloud computing providers are allowing businesses to build hybrid systems, maintaining some information in the private cloud and relying on third party services for a majority of their IT and network support. Dropbox competitors are allowing users to have their cake and eat it, too.

Dropbox is tempting as a sleek and easy to use storage and collaboration tool. Please see the attached briefing for an overview of its technologies, key issues surrounding cloud computing and the ways in which this technology is developing.

Sincerely,

Bailey Berry

**Dropbox: Cloud Computing Solution for Business**

As more and more industries are relying on cloud computing to provide secure storage to their digital files and access to content across departments and institutions, Dropbox has marketed itself as a Infrastructure as a Service cloud computing solution for creative businesses.

- Dropbox offers Encrypted Block technology for the secure transfer and storage of files
- New features allow the creation of and collaboration on files on their platform
- Dropbox faces growing concerns of the security of its technology and its privacy standards for user data
- There is fierce competition from other cloud computing services, which offer more diverse applications and customized API's and computing capabilities
- With growing concern of privacy in public cloud providers, more businesses are turning to Private, hybrid and community cloud solutions

**Background**

When explaining why he created Dropbox, Drew Houston describes becoming frustrated with having to use a USB drive to transfer files between his work computer, home computer and laptops- which he frequently forgot to bring with him. At one point, one of his hard drives crashed and he lost a huge bulk of his content. He also struggled with attempting to share large amounts of data with colleagues through multiple email attachments[1]. Dropbox emerged to store and share large amounts of data using a system that was accessible across multiple devices and to multiple users.

Dropbox was launched in 2007 and had over 500 million users by the end of 2018.[2] It organizes its tiers of services offered into individual or team, each with different pricing plans. Differences in usage are divided on Dropbox's site into a few categories. "Dropbox core features" include cloud storage space, from 2 GB to "as much space as needed", access to a desktop app, access from any device able to connect to WIFI, and sharing capabilities secured with 256-bit and SSL/TLS encryption. "Content and accident protection" includes file recovery, remote device wipe, shared link controls and device approvals. "Productivity and sharing tools" refers to the tools Dropbox offers for sharing and working collaboratively on files stored in Dropbox. "Team management" is the tools offered for administrative control for larger companies such as billing, multi-team login, billing and audit logs with file event tracking. "Support" offers three levels of technical assistance: Priority email support, available to all users, Live chat support, available only to "professional" users and above and phone support, available to "standard" business users and above.[3]

[1] Ying, Jon "Meet the Team! (Part 1)"
[2] Trefis Team "Dropbox is Doing Well, But Looks Rich in the Face of Industry"
[3] "Choose the right Dropbox for you".

**Technology**

Dropbox is Infrastructure as a Service, which means it offers users software, hardware, networks and IT support. Storing data on the cloud means that instead of data being stored locally in your own hard drive, it is sent to remote data centers through the internet. These data centers are made up of series of network servers clustered together in racks and connected by routers. These systems are hooked up to a backbone, which connects the whole system to the internet. When your computer is also connected to the internet, you can send your data in the form of packages to the backbone and then into the data center, where it is stored in several different places.

Dropbox has data centers across the United States in Washington, California, Texas, Illinois, New York and Virginia. It has expanded its data centers internationally to Germany, Australia and Japan where more secure storage is available for some Dropbox Business users.

Within a data center, Dropbox has developed what it calls a Quad-Plane, 3-Tier fabric. This system was developed to address issues with storage capabilities and scalability and address design issues with limitations of stacking rigid hardware. This new system unifies ASICs at every tier (Application-specific integrated circuit- the microchip which holds all of the potential logic gates, but created specifically to handle cloud computing/ data transfer operations), meaning that data can more easily communicate between different pieces of the stack. The fabric uses ECMP (Equal-cost multi-path routing), which allows for several “best” routes for data to take to get to one destination. Typically, routers have to compute which particular route data must take to get to the proper destination. By offering more than one route, data transfers should occur more quickly. Individual Racks are organized into series of sixteen, called a “Pod”. Dropbox uses eBGP (external border gate protocol) to communicate between its clusters and iBGP (internal border gate protocol) to communicate transfer of information within its clusters. Connections within and between these building blocks in the fabric are made with Multimode fiber optic cables, the longest one being 140 feet.

Dropbox has something called a “Magic Pocket”, which is the technology that manages the storage of data. Dropbox stores data using block technology. This means that files and the metadata about the files are split into separate blocks of bits or data, encrypted, duplicated and stored separately for more secure storage. This is all done ultimately using Solid State Drives. Incoming data is accepted by front end nodes, which determine where to store the data. The data is split into blocks, which are identified by a unique hash and assigned a checksum for ensuring the authenticity of data. Blocks are copied several times and duplicates are then stored in different “zones”, which refer to regions of the United States where data centers are located. Blocks are grouped together by a Block Index into buckets with other blocks, which are then grouped into volumes. The Block Index stores these locations by associating the hash with a cell, bucket and checksum. These volumes are written onto physical discs where they are stored in different cells.

**Key Issues and Future Trends**

One of the most important issues with the use of Dropbox and the use of cloud technology in general is concern for privacy and security. While Dropbox is proud of its encryption services and block technology, which should ensure the secure transmission of information between networked systems, there are instances where data is unencrypted and thus vulnerable to security threat. Dropbox itself mentions in its privacy policy that there are some employees who may regularly access user data for

legal purposes, these employees can potentially unencrypt and access your files at any time. There have been several data breaches at Dropbox, including in 2016 when 68 million Dropbox Account email addresses and passwords were published online.[4] Dropbox tests its infrastructure by using third-party services, such as "Hacker One", which invites internet users to find vulnerabilities and offers a bounty for any found and reported to Dropbox.[5]

Dropbox admits that it collects information regarding your account (name, email address, phone number, payment info, etc.); "Your Stuff"- the records and files you store in Dropbox along with "Related information" regarding your profile and "the size of the file, the time it was uploaded, collaborators, and usage activity"; Contacts; Usage Information- actions you take in your account; and Device Information (IP addresses, type of browser and device you use, webpage you visited before Dropbox and your location).[6] It also mentions that it uses Cookies and pixel tags and targets marketing towards its users and towards others associated with its users. Dropbox shares your information with "Trusted third parties": various incorporated businesses that offer support on Dropbox applications. They access your data "only..to perform tasks on Drobox's behalf". Added to this is concern about government interference. This is especially a concern in the United States where the Patriot Act allows the government to access any data stored in a provider's jurisdiction. According to Dropbox, you can request that they stop, limit use of or delete personal data- but only if "we have no lawful basis to keep using your data", defining "lawful basis" as: "to provide to Dropbox Services to you pursuant to our contract with you; in furtherance of its legitimate interests in operating our services and businesses".[7] Its recommendations for correcting or deleting your personal data are either changing your account information or deleting your Dropbox.

Beyond concerns about the security of files and collection of personal data, businesses who use Dropbox as a primary way of storing important information may also be concerned about legal human resources issues and compliance standards. Dropbox Business offers some assistance in this by allowing users to limit access to certain files, monitor changes to them and recover lost versions making Dropbox a digital and more sophisticated version of the locked filing cabinet. Dropbox also offers features such as "HIPAA Compliance" and Billing and audit logs. Still, there remains the possibility that Dropbox, a "trusted third party" or a government agent could access sensitive files and that this information could be leaked. Further, in a report for the Canadian Journal of Information and Library Science, Jessica Bushey et al. highlighted these concerns with maintaining reliability and authenticity of records in the cloud: : unauthorized access to information and records, privacy breaches, loss of access to and management of information and records, alteration of information in the cloud, lack of transparency regarding account management, server locations, data destruction and recovery.[8]

In response to these serious security concerns, many businesses are exchanging "public" cloud computing, such as a service like Dropbox, for "private" cloud computing, or a combination of both services, which is called "hybrid". Private cloud computing requires that companies provide their own networks for storage often located on site or close by. This option means that companies will have to

[4] Mendelsohn, Tom. "Dropbox hackers stole e-mail addresses, hashed passwords from 68M accounts"
[5] "Security"
[6] "Dropbox Privacy Policy".
[7] "The Dropbox Privacy Policy: Frequently asked questions."
[8] Bushey, Jessica et al. "Cloud Service Contracts: An Issue of Trust" p. 142

take on a large portion of the costs for creating and maintaining stacked network technologies. Further, the growing quantity of digital information being produced by businesses often requires physically large and technologically sophisticated storage systems. To ease this cost, many businesses opt for "hybrid" cloud computing. For example, the University of Illinois uses Microsoft and Google suites for email and some team collaboration, but offers U of I Box – a private cloud – for sensitive files that require especially secure storage.[9]

U of I also uses Amazon (AWS) Suite for many of its cloud computing needs. Unlike Drobox, Amazon advertises hybrid cloud systems and offers a diverse set of cloud computing applications that allow businesses to pick and choose between simple Software as a Service models and customizable Platform as a Service applications.[10]Another of Dropbox's main competitors, "Box" offers a wide and diverse array of applications and API development capabilities meant to address the privacy needs of many different businesses, including medical and biological scientific labs, which increasingly rely on cloud systems for publishing and storing raw data.[11] IBM and Microsoft have also incorporated more flexible Platform as a Service models that allow businesses to decide how much of their network they would like to control and what they can rely on third party service providers to manage. Finally, libraries and smaller archives are also developing "community clouds", where several institutions share the maintenance and development of private data centers and networks, which not only distributes cost, but fosters greater collaboration between institutions in related fields.[12]

Cloud services that that enable companies to have some control over securing sensitive files, but relieve the burden of maintaining complex and dense hardware stacks, are taking over the market.[13] Many businesses are not only opting for these providers, but are choosing to combine applications from more than one provider. This has introduced a new service called "Cloud Brokers", which facilitate interoperability between different service providers. These brokers promise to stay informed about up-to-date cloud technologies so they can continue to advise clients about how to build the best hybrid cloud systems and ensure they operate smoothly as a complete system.[14] Some cloud computing services, such as AWS and IBM offer their own cloud brokerage services and promise interoperability between their applications and other third-party providers.

Compared to these increasingly complex competitors, Dropbox's services are fairly simple. While it is advertising itself as a business solution, it is not well-equipped to handle the sophisticated storage and software needs of many large companies. Dropbox offers a user-friendly interface and simple storage solutions at the cost of security and control over file access and network customizability.

[9] "Types of Cloud Computing: Private, Public and Hybrid Clouds"
[10] "Cloud Storage with AWS".
[11] "Box Platform, Extend the power of Box with APIs".
[12] Grant, Hurley. "Community Archives, Community Clouds: Enabling Digital Preservation for Small Archives."
[13] Drake, Nate and Brian Turner. "Best cloud computing services of 2020: for Digital Transformation."
[14] Yedlin, Debbie. "Pros and Cons of Using a Cloud Broker".

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