The PRCToken White Paper

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Abstract

With the rapid growth of connected Internet of Things (IoT) devices and online media traffic demand, and the increasingly conspicuous limitations of the Cloud, the Fog has emerged to be a promising research topic that is breeding another transformation in computing. Pear is a start-up implementing fog computing technology from concept into reality. Conforming to the "XaaS" philosophy, incorporating the crowdsourcing paradigm, and agglomerating the Sharing Economy, Pear is able to scale up a network with a pool of resources, provide reliable services and make a subset of fog touch the ground.

In this white paper, we provide a retrospective view of development in related fields over the past two decades, with highlights on the lessons learned. We abstract them to metaphors and analogies that indicate and inspire our philosophy, choices and decisions. We generalise the working fashion to a unified model, and we give solutions to key problems. We also introduce several of Pear's on-going business projects from both technological and business perspectives. Algorithmic, protocolic and architectural design principles are also discussed, along with a business plan.

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Chapter 1

Introduction

Before there were mobile devices, there was media content. But now that there are mobile devices, there is even more media content, and both media content consumption and generation lie at the heart of mobile applications.

For thousands of years, people have never exhausted their desire to feast their eyes on something visually and "illusionally" attractive (see Figure 1.1). Since photography and television devices were invented, people have begun to spend more and more time on virtual scenes in front of their eyes, be it a photograph, a movie screen, a TV screen, a PC monitor, a tablet PC, a smartphone, or a VR[1] headset. Small wonder that VR and AR[2] are subsequently and concurrently two of the hottest topics in consumer electronics today.

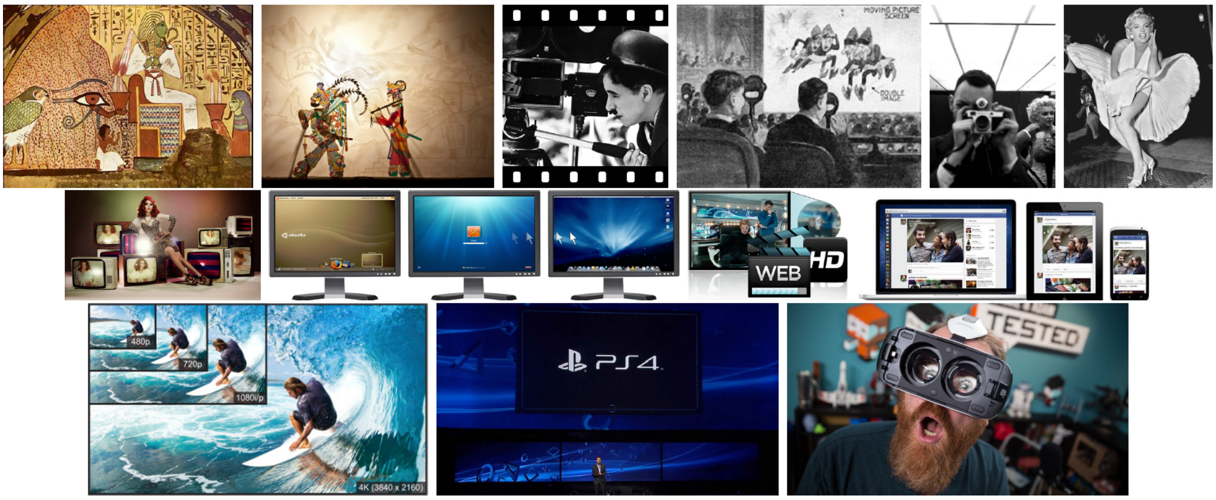

Figure 1.1: Human's visual feasts in history.

Billions of people now enjoy huge screens and high definition videos. For entertainment, people are now greedily expecting to experience as many details in the virtual world as in reality. This is why nowadays we have 720p, 1080p, 2K, and 4K resolution pictures and videos, with 8K to 16K coming in the near future. Moreover, since VR technology tends to be prevalent in gaming and entertainment, billions of mobile devices are ready to fetch these super high definition VR videos from the Internet to

[1]Virtual Reality. Example phenomenal device: Oculus of Facebook.

[2]Augmented Reality. Example killer app: Pokemon Go by Niantic.

please their masters. For Internet television, the elementary-level resolution is 1080p and the standard-level is 4K; in VR/AR, 4K is considered basic, while it is expected that the standard-level will soon become 16K.

What kind of network throughput problems will we face with the rise and rapid use of VR/AR devices? Figure 1.2 roughly illustrates the relationship between the resolutions and the bitrates required with the H.265 (HEVC) coding standard.

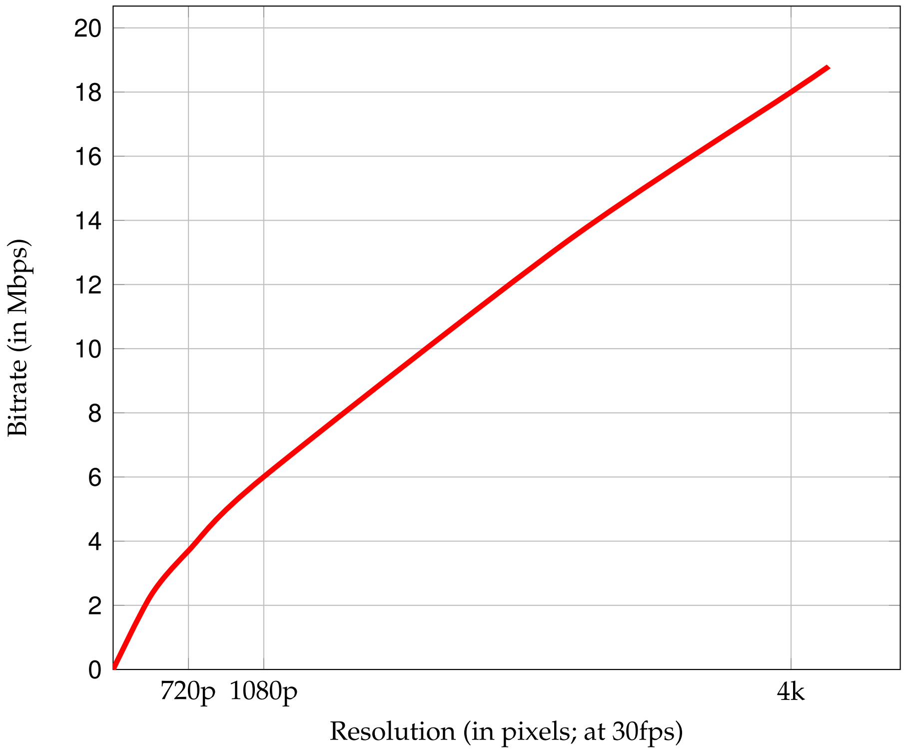

Figure 1.2: Bandwidth required for delivering various videos.

To put this in perspective, let's look at the coming explosion in demand for network throughput. With the rapid progress of low-power wireless communications and the evolution of micro-sensors, the not-really-new concept of IoT begins to touch ground in novel fields like smart wearables, smart agriculture, smart homes, smart buildings, smart environments, smart cities, smart transportation, smart enterprises and smart hospitality. It is an undoubted trend that there will be an exponentially growing number of devices connecting to the Internet. In 2011, Cisco predicted that there would be 25 billion devices connected to the Internet by 2015 and 50 billion by 2020 [?].

Just imagine if these devices continually send 1K total-sized `HeartBeat` messages to the cloud in 1-second intervals. What kind of pressure will this put on backbone networks and cloud services in general? What challenges will network engineers face in coming years? And what new solutions will emerge?

These challenges have forced the emergence of fog computing, a fairly new paradigm which basically moves some elements of Cloud Computing closer to the end users, especially in a machine-to-machine (M2M), collaborative platform; these elements include compute, storage, and networking devices [?].

Pear Limited, hereinafter referred to as "Pear", is an innovative start-up company that originated at the *Foggy University*[3] campus and mainly focuses on implementing fog computing technology from concept to reality. The business idea leverages future technological trends to meet real needs.

Research on fog computing is still in its very early stages. On 19 November 2015, ARM, Cisco, Dell, Intel, Microsoft and Princeton University formed the OpenFog Consortium. It plans to set up seven different working groups aiming at solving problems in fog computing, but so far it has only published one architectural white paper[4]. Therefore, Pear is neither required nor able to address all aspects of fog computing. Pear will first follow, implement, and practise a specific category of fog — a relatively "stable" kind of fog, serving in-between the Clouds and the clients. It hopes it can get a foothold in this new market before the rules are established and before too many giant players join the game.

From one angle, Pear Fog is a descending cloud — a pool of compute, networking and storage resources across the core through to the edge of the Internet. From another point of view, Pear Fog is a new and improved powerful peer-to-peer (P2P) system incorporated within a crowd-sourced paradigm, providing Infrastructure as a Service (IaaS), Platform as a Service (PaaS), or Software as a Service (SaaS) in a "Uber"-like way. In addition, Pear Fog is compatible with and complementary to existing clouds. One of its goals is to serve as a coordinator of Cloud-Fog coordinators.

We plan to implement and operate a business-friendly subset of fog with crowd-sourcing that will help some giant CPs and CDNs cut their costs and provide better services to end-users. Hereinto, the end-users can pair with Pear to form a pool of computational resources. Pear will schedule the resources to process business tasks and rebate a portion of its profits to the end-users accordingly.

To provide stable and sufficient fog services, Pear has to source and distribute a large number of fog devices powered by Pear's software, and it has several strategies to do so.

This thesis documents the following three contributions:

- It presents a thorough survey of related fields along the pathway from the early days of networking to the Cloud to the Fog.
- It proposes several effective approaches to offer fog services, in terms of software framework, network design, use cases, *etc.*
- It describes approaches to scale up the fog network, actualise the technologies, and from some mutually beneficial alliances to get off the ground and survive as a viable business in a cutthroat market.

We present an in-depth historical analysis of related areas. From the rises and falls of different technologies, as well as the ups and downs of different concepts, we share illuminating lessons. From these lessons, we summarise the key points and identify the best practices. The lessons stated in Chapter **??** have inspired our decisions.

[3]It is a homophone of HKUST in Cantonese, because people in Hong Kong call it "Foh Gei Dai Hok"; "Foh Gei" sounds like "Foggy" and means "Science and Technology", while "Dai Hok" means "University". Interestingly, every spring the HKUST campus is rather foggy because of its proximity to the sea. This fact makes the university live up to its "Foggy" nickname.

[4]`https://github.com/OpenFog/white-papers/tree/master/Architecture`

We have decided to implement a business-friendly subset of fog first. We then provide further details on what we have chosen to do. Using analogy reasoning, we have arrived at a resolution to initially focus on single critical endeavour: implementing a multi-functional WebRTC gateway in C language. To make this business feasible, we need a stable hardware carrier with sufficient storage. We further analyse the types of fog resources and their dominant battlefields, and we generalise all the crowdsourcing fog services' model. We also analyse where fog will serve better than cloud, especially for content delivery. Finally we conclude by three medium-term projects. Thus, Chapter **??** comes why, what and how we will develop our software and hardware products.

To create a sustainable business, we carefully consider various product, price, place, promotion, partnership, and funding and financial plans. These are presented in Chapter **??**.

Chapter 2

CDN TSD(TRUST-SECURITY-DEVELOPMENT)

2.1

Pear

2.1.1

2.1.2

TSD

2.1.3

POS(Proof of stake) tnc

$$c = c_h + c_s + c_b + c_d$$

$w_h = \frac{c_h}{c}, w_s = \frac{c_s}{c}, w_b = \frac{c_b}{c}, w_d = \frac{c_d}{c} w_h + w_s + w_b + w_d = 1 w_h = 0.2, w_s = 0.3, w_b = 0.2, w_d = 0.3$

$ic(i)$

$$c(i) = c_h(i) + c_s(i) + c_b(i) + c_d(i)$$

$c_h(i) i p_h(i) \sum_{k=1}^{n} p_h(k)$
$c_s(i) i p_s(i) \sum_{k=1}^{n} p_s(k)$
$c_b(i) i p_b(i) \sum_{k=1}^{n} p_b(k)$

$c_d(i) i p_d(i) \sum_{k=1}^{n} p_d(k)$

$$c(i) = c \times \frac{p(i)}{\sum\limits_{k=1}^{n} p(k)}$$

$p_h 1$

p_s

$$p_s = \log\left(\frac{s}{250} + 1\right)$$

$s s = s_u + \frac{1}{2} s_a s_u s_a$GB

$p_b b_u b_d \min(b_u, b_d)$

5min288288$\mathbf{d}$/5min$\mathbf{v}$ $p_d = \mathbf{d} \cdot \mathbf{v}$

Chapter 3

Cooperation Cases

Based on the increasingly mature CDN content sharing platform, the Gehua Chain project team will focus on "building a trustable, smart, and effective new shared economy", continuously to exploit the blockchain technology capabilities and enrich the intelligent applications, and build a TSD (Trust-Security-Development) smart ecology.

3.1 Gehua Chain

Gehua Chain is one of Pear's tailored set of solutions according to the needs of its partners.

The Gehua Token is a virtual digital proof generated by the Gehua Chain project. Via sharing bandwidth, storage, compute, and other idle resources, Gehua Chain router users can mine tokens issued by the Gehua team. The number of tokens a user receives is according to his/her weight of contribution. All the proofs are stored in secure Blockchain. Each of the Gehua Chain router miner users has an account, a password or certificate, and can take effective operations on top of his/her proofs.

3.1.1 Use Scenarios of the Gehua Token

The Gehua Token works as the exchange medium for the TSD smart sharing ecosystem in two ways:

1. It is used by many content providers to purchase TSD services (*e.g.* Fog CDN services). As such, we define it as a utility token.

2. Miners can use it to exchange for digital contents or other digital services (*e.g.* membership fees). Here the Gehua Token is a currency token as it is a medium of value exchange.

The Gehua token is not an asset token, therefore it does not offer any dividends profits or voting right. While there will be direct or indirect ways to exchange Gehua Token to or from other digital cryptocurrencies or fiat currencies, the main purpose of Gehua Token is to be the utility token within the Gehua Chain ecosystem.

3.1.2 Distribution of the Gehua Token

The Gehua Token adopts the PoS (Proof of Stake) algorithm, taking the device's hardware (compute and memory) capability, bandwidth capability, storage capability, traffic contribution, and online duration into account.

In each digital PoS period t, n is the total number of valid online nodes, c is the total amount of tokens to be issued, then c is divided into 4 parts: hardware capability, bandwidth capability, storage capability, traffic contribution:

$$c = c_h + c_s + c_b + c_d \tag{3.1}$$

We denote their weights as: $w_h = \frac{c_h}{c}, w_s = \frac{c_s}{c}, w_b = \frac{c_b}{c}, w_d = \frac{c_d}{c}$, apparently $w_h + w_s + w_b + w_d = 1$. Here is a sample tuple of values: $w_h = 0.2, w_s = 0.3, w_b = 0.2, w_d = 0.3$.

The digital certificate $c(i)$ obtained by node i consists of 4 parts:

$$c(i) = c_h(i) + c_s(i) + c_b(i) + c_d(i) \tag{3.2}$$

$c_*(i)$ is decided by the ratio of the current total circulation in one category c_* multiplied by the power value $p_*(i)$ of the node i to the sum of the corresponding capability/contribution values of all nodes:

$$c_*(i) = c_* \times \frac{p_*(i)}{\sum\limits_{k=1}^{n} p_*(k)} \tag{3.3}$$

For p_h, we set the configuration of the first generation router, as the minimum configuration of hardware to mine the Gehua Token, and we assign it the benchmark value of 1.

For p_s,

$$p_s = \log\left(\frac{s}{S} + 1\right) \tag{3.4}$$

where s is a measure for the storage space available for mining, and

$$s = s_u + \lambda s_a \tag{3.5}$$

where s_u is the space that has already been used for mining, and s_a is the unused space available for mining, S is a measure adjustment parameter and its initial desirable is 250, all in GB. Following the principle of maximum entropy, we set $\lambda = \frac{1}{2}$.

For p_b, we take the minimal of uplink bandwidth b_u and the downlink bandwidth b_d, namely $\min(b_u, b_d)$.

We calculate the Internet data traffic that each node contributes every five minutes and we get a total of 288 values a day. We record it as a vector $\mathbf{d}$ of length 288. In the region/time zone where the node is located, the value of Internet data traffic of each time slot corresponding to 5 minutes is not the same, and is denoted as vector $\mathbf{v}$. Then we have:

$$p_d = \mathbf{d} \cdot \mathbf{v} \tag{3.6}$$

We can set maximum values for p_h, p_s, p_b, p_d, no additional mining reward a node can earn if its power value exceeds the given one. The weights w_h, w_s, w_b, w_d, S and λ will also be voted on, updated and publicised through a committee constitutes of three parties: miners, fog service clients, the Gehua team.