雾计算（ fog computing ）

雾计算是相对于云计算而言提出的一个概念。

雾计算和云计算一样，十分形象。云在天空飘浮，高高在上，遥不可及，刻意抽象；而雾却现实可及，贴近地面，就在你我身边。雾计算并非由性能强大的服务器组成，而是由性能较弱、更为分散的各类功能计算机组成，渗入工厂、汽车、电器、街灯及人们物质生活中的各类用品。

雾计算，又名 fogging ，在该模式中数据、（数据）处理和应用程序集中在网络边缘的设备中，而不是几乎全部保存在云中。

这种集中意味着数据可以在本地智能设备中进行处理而不需要发送到云中进行处理。雾计算是处理连接互联网的设备数量不断增加的需求的一种途径，它有时也指物联网 (IoT) 。

在物联网场景下， 任何一个自然或人造对象都可以被分配一个 IP地址并具有在网络上传输数据的能力。类似的这些事物可以创造大量数据。 Cisco 提供了一个喷气发动机的例子，他们说在一个半小时内可以就其性能和状态创造 10千兆字节（ TB ）的数据。传送所有数据到云中并传回响应数据带来大量对带宽的需求，这需要一个相当长的时间并可能遭受延迟。在雾计算环境中，大量处理将在一台路由器中发生，而不必进行传输。

雾计算将云计算模式扩展到网络边缘。虽然雾计算和云计算使用了相同的资源（网络、计算和存储），也共享了许多相同的机制和属性（虚拟化、多租户），但这种扩展是有意义的，因为其中存在的一些根本性差异导致雾计算被开发出来： 为不符合云计算模式的应用程序和服务定址。

这些应用程序和服务包括：

? 应用程序要求非常低的和可预测的延迟时间。 云计算从很多实现细节方面释放用户， 包括计算或存储发生的精确位置信息。 然而， 这种自由是可以选择的， 当一个显著程度的延迟不可接受时（比如游戏、视频会议），遇到很多这类情况，自由又变成了不利因素。

? 地理上分布式应用程序（管线监测、监测环境的传感器网络）。

? 快速移动应用程序（智能互联车辆、互联铁路）。

? 大型分布式控制系统（智能电网、互联铁路、智能交通信号灯系统）。

Cisco的 Ginny Nichols 创造了雾计算这个术语。这个比喻出自 “雾是接近地面的云 ”的这个事实，正如雾计算在网络边缘集中处理。据 Cisco介绍，在地理分布和分层结构问题上，雾计算延伸了云计算的边缘。

“ Cisco雾计算 ”是一个注册名称，大体上对社区开放。

雾计算的概念在 2011 年被人提出， 在 2012 年被作了详细定义。 正如云计算一样， 雾计算也定义得十分形象。云是高高的天上，十分抽象，而雾则接近地面，与你我同在。雾计算没有强力的计算能力，只有一些弱的，零散的计算设备。雾是介于云计算和个人计算之间的，是半虚拟化的服务计算架构模型。当我们发现云计算时，开始时欢呼雀跃，但接下来却发现实施起来很困难，

数据中心现有的发展阶段根本满足不了云计算这个高层计算算法，这就为雾计算的产生提供了空间。也有人提出云端计算，更加强调边缘计算设备的作用，其含义和雾计算都类似，都是希望计算要在物理节点上分散，而不是集中。

雾计算是以个人云，私有云，企业云等小型云为主，这和云计算完全不同。云计算是以 IT 运营商服务，社会公有云为主的。雾计算以量制胜，强调数量，不管单个计算节点能力多么弱都要发挥作用。 云计算则强调整体计算能力，一般由一堆集中的高性能计算设备完成计算。雾计算扩大了云计算的网络计算模式，将网络计算从网络中心扩展到了网络边缘，从而更加广泛地应用于各种服务。雾计算有几个明显特征：低延时和位置感知，更为广泛的地理分布，适应移动性的应用，支持更多的边缘节点。这些特征使得移动业务部署更加方便，满足更广泛的节点接入。现在国家在大力发展物联网，物联网发展的最终结果就是将所有的电子设备，移动终端， 家用电器等等一切都互联起来，这些设备不仅数量巨大，而且分布广泛，只有雾计算才能满足，现实的需求对雾计算提出了要求，也为雾计算提供了发展机会。有了雾计算才使得很多业务可以部署。比如：车联网。车联网的应用和部署要求有丰富的连接方式和相互作用。车到车，车到接入点（无线网络， 3G，LTE，智能交通灯，导航卫星网络等），接入点到接入点。雾计算能够为车联网的服务菜单中的信息娱乐，安全， 交通保障等服务。 智能交通灯特别需要对移动性和位置信息的计算，计算量不大，反对时延要求高，显然只有雾计算最适合。试想如果城市中的所有交通灯都需要有数据中心云计算来统一计算而指挥所有交通灯，这样不仅不及时也容易出错。智能交通灯本意是根据车流量来自动指挥车辆通行，避免无车遇红灯时， 也要停车等到绿灯再走， 那么实时计算非常重要， 所以每个交通灯自己都有计算能力，从而自行完成智能指挥， 这就是雾计算的威力。没有云， Nest 智能恒温器收集到再多的数据，也无法分析，从而总结出一家人的生活节律；没有云， Jawbone 收集来的步数等等数据，就很难跟别人进行比较。即便如此，“云”对于智能硬件来说，依然太重。

What is fog computing?

The term “fog computing” or “edge computing” means that rather than hosting and working from a centralized cloud, fog systems operate on network ends. It is a term for placing some processes and resources at the edge of the cloud, instead of establishing channels for cloud storage and utilization.

Fog computing tackles an important problem in cloud computing, namely, reducing the need for bandwidth by not sending every bit of information over cloud channels, and instead aggregating it at certain access points. This type of distributed strategy lowers costs and improves efficiencies. More interestingly, it’s one approach to deal with the emerging concept of Internet of Things (IoT).

Fog computing extends the cloud computing paradigm to the edge of the network to address applications and services that do not fit the paradigm of the cloud due to technical and infrastructure limitation including:

? Applications that require very low and predictable latency

? Geographically distributed applications

? Fast mobile applications

? Large -scale distributed control systems

Applications of fog computing

Tech giants like IBM are the driving force behind fog computing, and link their concept to IoT. Today, there might be hundreds of connected devices in an office or data center, but in just a few years that number could explode to thousands or tens of thousands, all connected and communicating. Most of the buzz around fog has a direct correlation with IoT. The fact that everything from cars to thermostats are gaining web intelligence means that direct user-end computing and communication may soon be more important than ever. The following are some of the practical examples:

? Connected cars: It ’s ideal for connected cars, because real -time interactions will make communications between cars, access points and traffic lights as safe and efficient as possible.

? Smart grids: Allows fast, machine-to-machine (M2M) handshakes and human to machine interactions (HMI), which would work in cooperation with the cloud.

? Smart cities: Fog computing would be able to obtain sensor data on all levels of the activities of cities, and integrate all the mutually independent network entities within.

? Healthcare: The cloud computing market for healthcare is expected to reach $5.4 billion by 2017, according to a MarketsandMarkets report , and fog computing would allow this on a more localized level.

A closer look at fog computing shows that it is about taking decisions as close to the data as possible. Hadoop and other big data solutions have started the trend to bring processing close to the data ’s location. Fog computing is about doing the same on a larger scale. You want decisions to be taken as close to where the data is generated and stop it from reaching the cloud. Only valuable data should be traveling cloud computing networks.

There are economical advantages to using fog computing. All that is needed is a simple solution (or multiple solutions) to train models and send them to highly optimized and low

resource intensive execution engines that can be easily embedded in devices, mobile phones and smart hubs/gateways.

To achieve this goal, fog computing is best done via machine learning models that get trained on a fraction of the data on the cloud. After a model is considered adequate, then it is pushed to the devices. Algorithms like decision tree or some fuzzy logic or even a deep belief network can be used locally on a device to make a decision that is cheaper than setting up an infrastructure in the cloud that needs to deal with raw data from millions of devices.

What is next for fog computing?

Fog computing can really be thought of as a way of providing services more immediately, but also as a way of bypassing the wider internet, whose speeds are largely dependent on carriers.

Google and Facebook are among several companies looking into establishing alternate means of internet access, such as balloons and drones to avoid network bottleneck. But smaller organizations could be able to create a fog out of whatever devices are currently around to establish closer and quicker connections to compute resources.

There will certainly still be a place for more centralized and aggregated cloud computing, but it seems that as sensors move into more things and data grows at an enormous rate, a new approach to hosting the applications will be needed. Fog computing, which could inventively utilize existing devices, could be the right approach to hosting an important new set of applications.

However, the movement to the edge does not diminish the importance of the center. On the contrary, it means that the data center needs to be a stronger nucleus for expanding computing architecture. InformationWeek contributor Kevin Casey recently wrote that the cloud hasn ’t actually diminished server sales, as one might otherwise expect. Hybrid computing models, big data and IoT have contributed to server requirements that may be shifting, but aren ’t really abating as some experts had predicted.

The IoT is a relevant bridge to some of the biggest issues dividing the cloud and the fog (like bandwidth, which could lead to a hybrid fog-cloud model) as organizations seek to balance their enterprise-grade data center needs with support for increasing edge network growth.