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Producer Mobility Support for Information Centric Networking Approaches: A Review

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Abstract

The mobility support for Information Centric Networking (ICN) was generally divided into three categories, the consumer mobility, producer mobility and network mobility. Producer mobility is the support for the mobile content provider, source or producer to relocate without disrupting content consumer and intermediate router for content name and its location. ICN is naturally supporting mobile consumer and provides some benefits to facilitate network efficiency and timely delivery of information to the users on mobile. This paper reviews an analysis of producer mobility support in some popular ICN approaches and summarizes some of its features, which provide support during mobility. In addition, a brief comparison between IP mobility and ICN mobility support were discuss and challenges were emphasized especially for NDN and CCN that doesn't support content producer mobility initially from their architectural design. Moreover, this review paper highlights on the mechanisms that facilitate the support of content produce in some approaches that can be used for the solution of other approaches.

Keyword: Content-centric architecture, producer mobility support, name-based rosolution, information centric networking

INTRODUCTION

The global mobile data traffic, multimedia traffic, voice and video data, real-time streaming, web pages, global network connectivity demands is highly increasing. Because of the number of Internet users' flourishes in daily basis, resulted to an ever-increasing demand for Internet support to meet the users' requirements and applications' needs. However, because of highly demand for data and services over the Internet, a lot of Internet problems were raises, such as: (i) scalability and efficiency of content distribution (ii) does not adequately support node mobility, multi-homing and multicasting (iii) data availability, security and authentication were another important issue (iv) does not provides better caching capabilities, (v) cause an unnecessary bandwidth usage (vi) persistent and location independent naming. In addition, the current Internet architectural technology TCP/IP based been used, turned out to be inefficient with adequate optimization of bandwidth when frequent congestion occurs, could not accommodate the multidimensional needs of data and information from the users. Furthermore, the problems of current Internet architecture are consequences naturally established from its architectural designed some years ago to address the sharing of resources [1], [2] and long distance communication [3].

CDN technology emerged to support the current Internet for scalable and efficient content distribution, as an effective approach that improve the quality of service [4] and P2P technology overlay to support the Internet [5]–[7]. A CDN is the assemblage of servers placed and distributed over a network, with the determined goal of reducing basic network load and improving performance of applications, by fetching predominant content immediate to the user or clients that requested it [7].

CDN provides server's load balance as static content served from EC servers nearest to the client certainly decreases the bandwidth required and provides rapid delivery of content across geo-locational server. Despite the apparent and efficient benefits of deploying CDN, there are some potential shortcomings. However, CDN demands supplementary and persistent DNS lookup, as static content may be served from available sources and provides potential security vulnerability, as content can be cached or distributed among the servers. Also, the overlay network frequently complicated the overall network management and provides difficulties for application development [6]. In addition, as the number of user accesses dramatically increases, CDN servers must have capability to handle large amount of content when dealing with flash crowds which resulted to high cost of management [8].

Consequently, the Information-Centric Networking (ICN) paradigm was proposed as a clean-slate redesign to supplement and replace current host-centric Internet architecture, evolves to access the data independent from its location by replacing IP addresses with content named to solve the problems of CDN and P2P as well as the current Internet in general. Xylomenos, et al. [3] in his surveyed article for information centric networking research, highlighted that, users were Interested mainly in accessing the data and other services such as, mobility support and better security, has directed many researchers into extreme consideration for essencial change of Internet architecture. Further, Information Centric Networking paradigm was offered to support more benefit such as network performance and scalability, any-casting and multicasting, authenticity and data integrity, mobility and multi-homing, in-network caching and reduction of network resources. Similarly by the nature of design in terms of security, ICN approach provides mobility support and security incorporation to manage and preserves privacy for both consumers and producers' locations [9]. In addition, some ICN architecture by default provides flow control through hop-to-hop request and reply mechanism;

even though, there are many challenges such as, scalability, privacy, mobility, application design, legal issues and deployment that needs more attention and proper solution for the ICN to be deployed and used extensively [10]. In general, ICN can also be called with terms like data-centric, content-centric, information-centric, content-aware and data-oriented networking, depending on the approach under broad area of ICN. Moreover, the ICN architectures are prominently known with content name in place of IP address and they are categorized in to flat, hierarchical and hybrid naming [10].

PRODUCER MOBILITY SUPPORT FOR ICN ARCHITECTURE

Mobility support allows mobile devices to relocate between different access point without disrupting the content availability and minimal hand-off delay. Hence, the mobility was divided into consumer, producer and network mobility [11]. Producer mobility is the support for the content provider to relocate without disrupting consumers and intermediate routers for content availability and its location within minimal hand-off time [11]. Figure 1 show data exchange between mobile producer and consumer before moving. In this section, we provide a review on some of the fundamental ICN architectures.

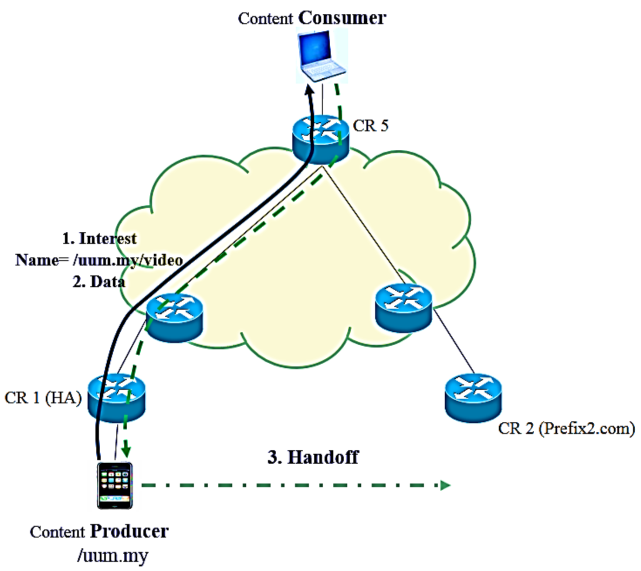

Figure 1. Content Producer and Consumer Data Exchange

Producer Mobility Support in DONA

Koponen et al. [12] proposed the pioneer ICN approach called DONA; focus more about replacement of host-centric network to data-centric network paradigm. DONA used flat namespace for NDO and self-certifying names to ensure the provision of data persistency and authenticity, that are organized around principals associated with named contents, public and private key pair and named contents [12]. Content names are organized in the form of P:L, where P is the principal's cryptographic publisher key and L is the principal's chosen label to identify the unique content name [5], [12], [13].

DONA used named-based routing using FIND rule and content catching to support information centric architecture. RHs are structured in the form of tree topology that symbolizes the BGP topology of the network and each client knows the whereabouts of its local RH [12], [13]. Any client authorized to provide a data or service with name P:L send a packet command REGISTER (P:L) to its local RH. After registration of the content or service, the consumer can send FIND request for the content to the connected RH. Upon recipient of the command, if such type of records exists, it will reply to the consumer, otherwise, forward it onward to next RH. Each RH reserves a registration table that maintained next hope information and distance to the copy. When a FIND (P:L) reaches RH and there was no records in the registration table, the FIND is forward to its parent RH up the tree until the source discovered. The content or data exchange occur directly from the source to destination using IP routing and forwarding, unless if there is cached copy along the RHs, the data exchange would be in the reversal through the RHs.

The content registration nature of DONA based on REGISTER and UNREGISTER is the mechanism responsible for providing mobility support to end system. When the mobile producer move from one PoA to another, the process of REGISTER will take place, once the register have been established and published all FIND packets will be forwarded to the new location [14]. Therefore, DONA support consumer mobilty by changing the RH and producer mobility would not have much challenges, because the content producer can smply re-register its content with the new RH whereby the new Interest need to be re-send or continue through a mechanism similar to Mobile-IP [13], [15].

TRIAD as the basic of content-centric architecture provides mobility support like DONA. Mobility support in TRIAD [16] was provided when hosts moves to new location the transport connection continue to function, although their address may change. The mobile host gets a temporary name from the new network and registers the temporary name with both home and guest network. The network can simply rebind the transport connection, based on name identification and the mobile host can request the home network to forward the packets to the guest network, using encapsulation [16]. This approach looks like indirection approach mobility support solution, which uses home router to redirect and forward encapsulated packets to new destination.

Producer Mobility Support in NetInf

Dannewitz et al. [17] proposed NetInf, a details ICN approach targets large-scale content distribution to replace or supplement current Internet architecture. NetInfo also used flat namespace for NDO [17] and self-certifying names as in [12], Further, NetInf used two models, name resolution and name-based routing for retrieving NDOs [5], [17], [13], also supports a hybrid of name-based routing and name resolution service with the provision of routing hints [17]. The source node has a choice to register with Name Resolution Service to publish NDOs or used routing protocol to announce routing hint. Furthermore, the hybrid approach were used for global connectivity with Border Gateway Protocol, (BGP)-like routing infrastructure combined binding with global name resolution service [17].

Figure 2 illustrates how name resolution and name-based routing works. In name-based routing approach, the client first forwards a GET request of NDO between nodes until a cached copy of NDO is found or its reaches the original server or source, the data are sent back to the client. Alternatively, the client can perform a name resolution as alternative if the routers not have enough routing information. The client forwards the request to the NRS, a DNS-like server to resolve and retrieved routing hints for that NDO name. The client used the hint to retrieved data from best available source. Also, the data are sent back to the client with object cached intermediary for subsequent used. These can either be merged as hybrid or used separately in the network.

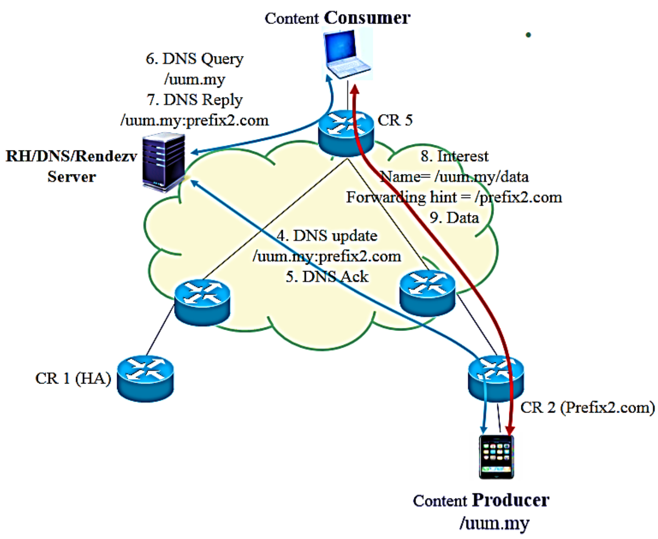

Figure 2. Name Resolution Services

In a case of producer mobility support, NetInf fundamentally support all kind of mobility and multi-homing. Producer mobility support is provided by regular updates of the routing information through name resolution [17] and the update is claimed that can be suitably handle by NetInf [13]. The NRS in NetInf can serve like a DNS-Like serves in the mapping-based approach of producer mobility support scheme, the mobile content producer can use both global and local NRS to publish its NDOs, in alternative uses routing protocol to announce a routing hint. The content consumer forwards the request to the NRS to resolve name and retrieved routing hint.

Producer Mobility Support in CONET

COntent NETwork architecture (CONET) was proposed to extend the CONVERGENCE [18] by improving network scalability using route caching technique [19]. In CONET nodes are classified in to four groups, name routing system nodes (NRSs), border nodes (BN), serving nodes (SN), end nodes (EN), and internal nodes (IN). The nodes exchanges information units for Data and Interest, labeled as Interest CIUs and named-data CIUs. EN refers to the user or client that sends Interest request to the network for named data through BN, border node locate at the border between different network and sub-system. Serving node can cached the named-data for subsequent used, advertise and provide it when necessary. SN can split named-data in to related sequence of bytes to represent series of named-data CIUs and transmitted by carrier packets, BN forward those carrier packets using routing mechanism supported by CONET. Internal nodes were optional in the architecture, deployed in CONET sub system to support in-network caching independent of BN. Name Routing Systems node used to promote route-by name process [20].

When EN sent an Interest CIU requesting named data, BN checks for the availability of the content if found in its cache, it would send back to the client otherwise CONET forward the Interest onward. If CONET Sub Systems (CSS) is IP network, the Interest should be forwarded-by-name with IP address overlay. IN along the path between the BN intercepts the Interest and checks it cache for relevant content, if not found forward the request to the destination as directed in the IP address with the help of in-path IP router between two BN. In short, three different topologies were being supported by CONET, clean slate over layer two (L2), CONET over IP layer and hybrid of CONET integrated in the IP layer [18], [19]. The CONET extended CONVERGENCE architecture based on a common container of a content-centric and publish-subscribe service model [20]. Also, PSIRP was expanded and explore further by PURSUIT for the model of publish-subscribe Internet architecture [21].

Mobility in PURSUIT/PSIRP is supported for both consumer and producer with the help of Rendezvous System (RS) [21], [22]. Consumer mobility can be supported using Re-subscribes to the content is the network, while producer mobility can be achieved using producer/publisher UNREGISTER and RE-REGISTER their new information when moving to new location and update information in the RS. In addition, information item is identified by Rendezvous Identifier (RI) for content or item specification and Scope Identifier (SI) for the location or scope in which content belongs. The RS mapped the RI and SI to form a Forwarding Information (FI). PURSUIT separate identity from location to support mobility [21]. However, the existing FIs would be invalidated and compute new routes for all consumers [13]. The nature of the producer mobility support is similar to DONA architecture [23] that uses RH, CONET and NetInf architecture [17] uses NRS, at the same time similar to the concept of DNS-Like mapping approach scheme of producer mobility support solution.

PRODUCER MOBILITY SUPPORT CHALLENGES

The mobility support concern in ICN was generally divided into three categories, the consumer mobility, producer mobility and network mobility. Producer mobility is the support for the content provider to relocate without disrupting consumer and intermediate router for content name and its location. Some researchers indicates the natural mobility support, as in [3] stated that, ICN supports and provides many benefits upon deployment for and multicast mechanisms and in-network caching, to facilitate network efficiency and timely delivery of information to the users on mobile. In addition, caching was proposed to remedy losses as a result of handoff in the situation of mobile IP, as the caching enhances and support client mobility seamlessly [24]. Further, caching is an integral part of ICN architecture to facilitates storage of caching NDOs therefore all ICN nodes such as mobile terminal and user-run home network were potentially have caches [5]. However, in case of consumer mobility almost all approaches were supporting it by default and architecturally mostly using in-network caching, which is the prominent feature of ICN after naming.

Consider Figure 3 that shows the scenario of consumer mobility support for general approaches of ICN. Assuming a content consumer connected to the same network looking for a video clip, sent an Interest requesting that video to the access point that can be a router or gateway. Once the router received an Interest, it will check if there is matching information with regards to the Interest, if found, the router retains the copy of the content and transfer back to the consumer, otherwise it will forward it to the next router towards the source as indicated as step 1. The source will forward the requested data back to the destination in breadcrumb style, labeled through step 2, while the intermediate routers have the capability to cache the replied data packets into its content store for subsequent uses.

Simultaneously, another consumer can request the same content by forwarding the Interest to the connected router that have the same content and the router can serve that consumer without transferring the request to the source. If consumer move to another location while receiving the content requested. After the establishment of connection to the network, it will re-issue a previously sent Interest that has not yet satisfied to the router. However, some architectures or approaches of ICN use other means to support mobility. For example, DONA uses RH to support both consumer and producer mobility and NetInf uses named resolution mechanism to support network, consumer and producer mobility.

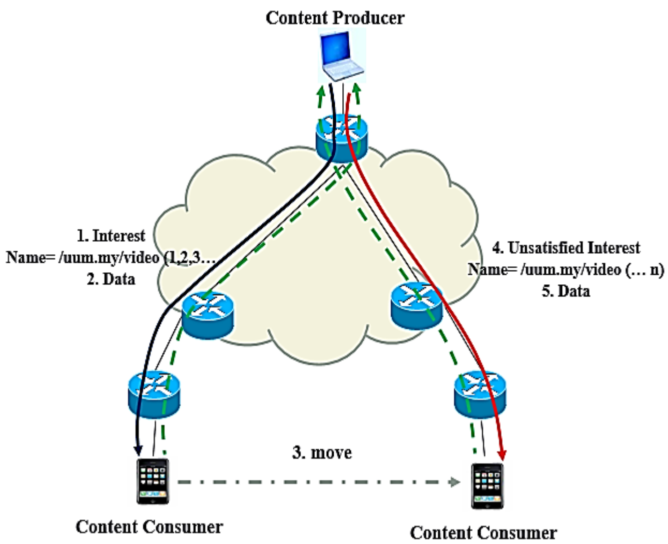

Figure 3. Consumer Mobility Support in ICN approaches

DONA manages and provides support for both consumer and producer mobility by changing edge RH attached to the host. For consumer mobility, any existing requests can simply be resend to the new RH to discover the new optimal source [12]. A client as producer is allowed to re-REGISTER its contents upon reestablishment of new session after relocation to new network's RH. Therefore, DONA supported producer mobility without much challenges. However, unlike NDN, CCN, NetInf and other approaches, DONA architecture relied on current Internet transport protocol TCP, for out-of-band content delivery from source to destination. In addition, the registration of source client must be renewed in certain period as it has a given life-time. Hence support for mobile producer was not guaranteed and the claimed of DONA as clean-slate was not justified.

Mobility and multi-homing supported in a global NetInf network was based on automatic dynamic updates in the NRS. NetInf support network, consumer/client mobility and producer mobility [5]. In terms of network mobility, LLC [25] provides very good support in routing and forwarding processes in NetInf. Also, GIN support client mobility without inflated look-up for routing table [26] and other network-based services such as private data networks, dissemination services, directory services, etc. Such services are implemented by network protocols or network applications, run over the GIN nodes. Content provider or producer mobility supported through NRS. When a copy of data moves between nodes, the movement result NRS update and accounts for the new location [5]. Moreover, mobility and multi-homing in NetInf can be realized based on dynamic NRS updates of routing information and the updates are standard operation in NetInf routing system for the announcement of the current location of IOs (Information Objects). Therefore, NetInf uses MDHT, LLC, GNI and HSkip as name-resolution mechanisms to support mobility for both the three types and improved stability and scalability of the network. However, there is no issue with NetInf as it was attained an excellent level with regards to mobility in general.

In PURSUIT and PSIRP, when consumer re-locates it simply uses publish/subscribe nature of the architecture to re-subscribes the content being used to the network [21], [13]. Therefore, consumer mobility was inherently achieved, however, producer mobility required to update the routing information, hence, producer mobility support was not guaranteed in PSIRP. In addition, producer mobility was likely complex as it does require updating of routing information while consumer mobility was relatively straight forward [15]. Also, For consumer mobility, a client can unsubscribed change the location and re-subscribed again, then routing path will be computed and seamless handing over should take place, while updating the routing sate of producer mobility is complex [5].

PRODUCER MOBILITY SUPPORT IN NDN/CCN

In NDN architectural perspectives, mobility was divided into content consumer and producer mobility. Feng et al. [11] and Saxena et al. [27] reported that consumer mobility was naturally supported in NDN, when mobile consumer relocates to another point of attachement (PoA), the unsatisfied Interest packets needs to be resend due to the consumer-driven nature of NDN. However, the content producer mobility faces many problems similar to mobility in IP architecture, such as routing table size scalling problem [28], introduces significant scallability challenge [13], offers long handoff delay and unnecessary Interest packet losses on transmission towards the old location of the content Producer [29], [30], for a large network domain the frequent routing update cost high bandwidth utilization [13], [31] and the problems of tunneling and triangular routing. The same problems arises in a case of CCN as NDN rooted from it [6], [7].

In NDN, when content provider relocates while sending a data to the consumer, the communication would be interrupted as shown in Figure 4. But the consumer will keep on sending unsatisfied Interest towards the old location of the producer. The interruption occurred due to the difficulty for producer in NDN network to move away or change from hierarchical location, which can result to stale breadcrumbs inside FIBs [28]. Unless if the producers on mobile can dynamically announce their namespaces to the network, hence producers on mobile must have a means for Interests to reach them.

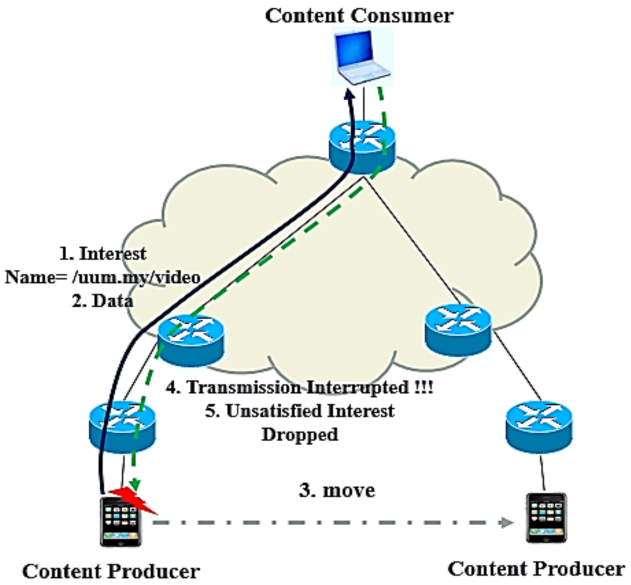

Figure 4. Producer Mobility Un-supported in NDN/CCN

For NDN and CCN to support producer mobility, the following issues need to be address:

i. There is need for the network to route pending or unsatisfied Interest packets to the location of producer on mobile

ii. After handoff process mobile producer must have any means for Interest packets to reach producer's new location

iii. There is need to decouple identifier and locator from the name prefix of NDN

iv. Mapping of identifier and new locator should be provided once mobile producer moved from on point to another

v. A means for mapping processes should be provided.

Table 1 summarized some ICN architectures with their mobility support, where almost all are supporting both consumer and producer mobility except CCN and NDN. For PSIRP and PURSUIT the support of producer mobility is not well highlighted, but producer mobility can be supported due to the nature of publish/subscribe strategy of PSIRP and PURSUIT.

Table 1. Summary of Mobility Support in ICN

Information Centric Network Approaches	Mobility Support	
	Consumer	Producer
DONA	Yes	Yes
TRIAD	Yes	Yes
NDN	Yes	No
SAIL	Yes	Yes
CCN	Yes	No
CONVERGENCE	Yes	Yes
NetInf	Yes	Yes
PSIRP	Yes	Not sure
PURSUIT	Yes	Not sure
CONET	Yes	Yes

OVERVIEW ON NDN AND CCN ARCHITECTURE

Architectural Principles and Benefits of NDN/CCN

NDN is completely new architecture whose design principles evolved from the successes of current Internet, that is IP architecture [3, 4]. There are six architectural principles that guided the design of NDN such as (i) the hourglass architecture centers on IP universal network layer, (ii) provision of security built in the architecture, (iii) retain and expand end-to-end principle, (iv) self-regulating flow-balance data delivery, (v) separation of routing and forwarding plane, and (vi) user choice and competition [33].

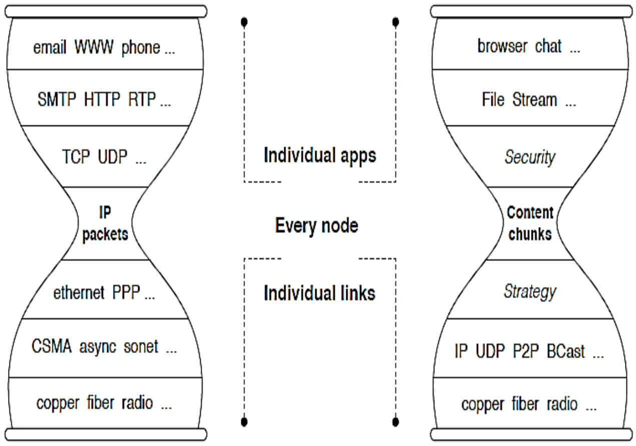

Figure 5. IP and NDN/CCN Hourglass Architecture [32]

The thin waist of the current Internet hourglass architecture located at the centers of universal IP network layer, shown in Figure 5. The waist provides the global interconnectivity; allow upper and lower layer technologies to transform independently designed for communications networks. Due to the rapid growth of data demand over the Internet, led the dominant use as a distribution network that make it complex for point-to-point communication protocol to solve [33]. However, NDN maintain the hourglass architecture, but replaces the thin waist with name objects or content chunks instead of IP addresses or communication endpoints in every node, as shown in Figure 5. The name can represent a data chunk, endpoint, command etc. The concept change by NDN provide named data security, flow balance, in-network storage, multipath forwarding, and solve end-to-end communication, content distribution and control problems [32].

Naming, Routing and Forwarding in NDN

NDN uses self-certifying named data that is secured with digital signature to achieve data authenticity, confidentiality and integrity which is one of the main objectives of NDN design. The architecture uses named data or content in hierarchical namespace structure for NDOs, thus, the naming scheme allows different application to choose its scheme independent of the network refers to opaque of the network [32]. Additionally, the hierarchical structure of naming represents the context and its relationship for each application.

To achieve routing and forwarding of packets, NDN uses named-base routing and possesses of two different types of packets, namely Interest and Data packets, as shown in Figure 7. Also, NDN node can be represented as client consumer, producer or a router, that maintains three data structure Pending Interest Table (PIT), Forwarding Information Base (FIB) and Content Store (CS), determines when and where to forward Data and Interest packets [4] as in Figure 6. PIT records and store any incoming Interest information, FIB maintained the Forwarding Strategy and decide when and where to forward Interest and CS is a temporary cache of data stored based on NDN caching policy.

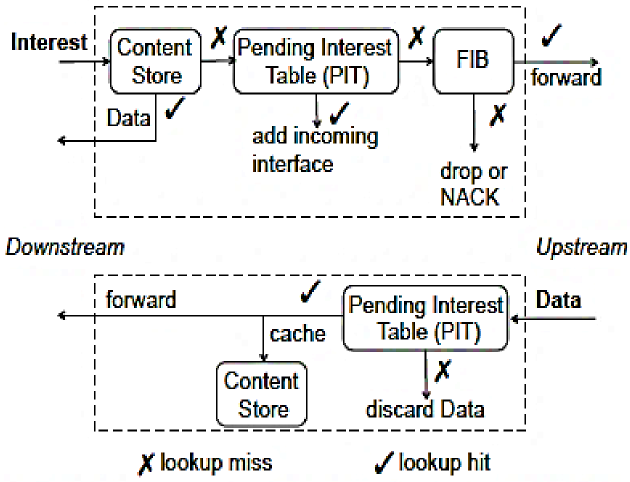

Figure 6. Node Data Forwarding Process for NDN/CCN [32]

An illustration in Figure 6, shows the forwarding processes on NDN node. When network was setup and client node (consumer) established a connection in the network. When the Consumer intends to retrieve data from the network, it will send an Interest to NDN router. On arrival of the Interest, the router checks the CS for matching data, if found its forward the data packets back to the consumer. Otherwise the router looks up the name content in its PIT for matching entries, if entry was not found it will records the name content and incoming interface and forward the Interest to the next hop through FIB, otherwise it will aggregate and records the interface only. The same process takes place up towards the content producer. Interest can be dropped on certain circumstances depends on forwarding strategy e.g congestion of upstream links or security breaches by suspecting Interest to be part of DoS [32]. Once the data producer received Interest request from the home router and in its PIT found the required content, it will forward the data packets back through interface received the Interest to the downstream interface recorded in PIT.

Interest Packet	**Data Packet**
Name	Name
Selectors (order preference, publisher filter, exclude filter…)	MetaInfo (content type, freshness period…)
Nonce	Content
Guiders (scope, Interest lifetime)	Signature (signature type, key locator, signature bits…)

Figure 7. Packet Format for NDN [32]

Additionally, each NDN/CCN node has the capability to cache data and save in CS for subsequent use based on NDN/CCN caching policy. Assuming another consumer want the same data requested by previous consumer, as its connected then forward its request, on the arrival of the Interest check the CS and found cached content requested by other consumer, the router will retrieve and forward it back to consumer without forwarding upward to the original producer. However, unlike in IP network architecture where each consumer must have a dedicated connection from source to destination, because it cannot support on-path caching. NDN/CCN also control looping by symmetrical nature of Data/Interest exchange targets hop-by-hop, unlike end-to-end packets delivery in respect to IP address model. Similarly, NDN/CCN routing and forwarding strategy eliminates some problems exist in IP architecture, such as NAT traversal, address management and space exhaustion since name assignment are not required in local networks, namespaces were unbounded and NDN do away with addresses.

MOBILITY CHALLENGES AND RESEARCH DIRECTION FOR NDN/CCN ARCHITECTURE

Naming becomes the most significant part of application design of NDN/CCN that qualifies support for multicast, content distribution, delay-tolerant networking and mobility [32]. By default, ICN proposed to support mobility, but many challenges aroused in NDN with regards to mobility as it was not fully supported like in NetInf and other approaches.

Zhu et al. [28] ascertains the unsupport of producer mobility in NDN. Even though, caching improves the performance and smoothens the mobile's handoff for consumer but it faces similar problems for mobile producer as in IP architecture, because of routing table size scaling problem still exist. To provide solution to the problem, Zhu et al. suggests separation and mapping between identifier and locator by broadcasting or intermediate nodes such as DNS servers [28]. Also, NDN/CCN uses hierarchical naming and route aggregation to improve scalability, but naming structure generates substantial challenges when providers move to different location and introduce significant scalability challenges. Hence, the problem can be lessened via caching and replication and provision of high-speed mobile producer hand-offs [13]. Ahlgren et al. [5] highlight the natural support of consumer mobility in NDN/CCN, but problems may arises for producer mobility. Also, expressed that, in consumer mobility there is no need to keep an association to a specific copy alive, instead, new connections can be establish and alternative copies cached at the new location can be used. NDN use NBR and hierarchical naming to aggregate route announcements, for a moving object new route needs to be announce and propagated to replace old routing information causing similar problem as in IP. Besides, producer mobility in NDN caused a serious problem that offers long handoff latency and unnecessary Interest packet losses on transmission towards the old location of the producer.

Recently, in survey articles for named data networking and mobility support in NDN by Feng et al. [11] and Saxena et al. [27], reported that consumer mobility was inherently supported in NDN while Producer mobility cannot be support or faces many challenges from initial architectural design of NDN. Nevertheless, there are different proposal to solve the producer mobility problem such as mapping based and locator free techniques [27]. In addition, [11] expresses that, although consumer mobility formerly supported in NDN/CCN by means of network caching, but still there are some problems needs to be addressed and yet producer mobility was not supported as a result of content named are not separated with location. In addition, to support producer mobility in NDN, another means is required to serve as the locator [11].

However, the above-mentioned researches, proved that producer mobility was really in needs of further research to find a concreate solution, for NDN/CCN architecture to assuredly replace and solves the shortcomings of the current Internet architecture with regards to producer mobility support.

CONCLUSION

This paper presented a review on producer mobility support and challenges that threatening some ICN approaches as future Internet architecture. ICN architectures in general, provide and achieved smooth handoff for consumer mobility without special mechanism. Unlike in IP architecture where by a mobile need to connect both old and new access point at the same time and required both mobile node and routers to used special protocols. Therefore, the nature of ICN provides much benefits over IP networks interms of mobility support. However, more challenges arises to make it better in support of mobile producer, which is not fundamentally supported in some approaches like NDN and CCN. In addition, NDN and CCN faces many challenges from initial architectural design causing similar problem as in IP. Therefore, further research needs to be conducted to address those challenges that are facing producer mobility support, to prepare the ICN approaches as future Internet architecture, to successfully replace the current IP Internet architecture.

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