Future Mobile Network Management With Attractor Selection

the 9th Annual Conference on Wireless On-demand Network Systems and Services
January 9-11, 2012, Courmayeur, Italy

Gen Motoyoshi *, Naoki Wakamiya †, Masayuki Murata †
* NEC Corporation, † Osaka University

Background

Efficient and Reliable System including Mobility Functions is Essential

Efficiency
Reliability
Mobility

Problem Statement and Proposal Summary

OpenFlow is a promising technology for the future Internet
- Programmable and software defined network per user basis
- Flexible path management
- Signaling cost or scalability issue
- Centralized control configuration
- Possibility of single point of failure

Attractor selection is a promising mechanism robust against environmental changes

We propose an extension of attractor selection onto OpenFlow network for the future mobile network design

Attractor Selection Mechanism

Biologically-inspired self-adaptive control mechanism
- Simple selection mechanism with feedback-controlled randomness
- Accurately attractor-based selection and randomly noise-based selection at the same time
- Robustness against the external fluctuations

Model: \( \frac{dm}{dt} = f(m) \cdot \alpha + \eta \)
- \( \alpha \): Activity (goodness of the current state)
- \( \eta \): Noise (randomness for a better state)
- \( m \): State (candidates for selection)
- \( f(\eta) \): Potential function for the states

Attractor selection mechanism is adapted to OpenFlow network for future mobile network
- Dynamic clustering management to alleviate inter-domain HO

Future Mobile Network w/ Attractor Selection

The best radio interface on the current condition is selected according to the attractor selection equation

(1) Best Radio Interface Selection Image

Select on an attractor basis

Mobile node
(1) Best Radio Interface Selection Model

\[ \frac{dm_i}{dt} = f(m_i) + a + q \]

Best interface is selected based on statistics of real-time link quality

\[ \frac{dm_i}{dt} = \max(m_{i-1}, m_{i-2}, ..., m_{i-k}) - m_i \]

\[ s(a) = a \left( \beta \exp \left( \frac{-a}{1 + \sqrt{a}} \right) \right) \]

\[ a = \frac{1}{1 + \exp \left( \frac{-a}{1 + \sqrt{a}} \right)} \]

\[ \eta \text{ Noise} = \text{natural AWGN (Additive White Gaussian Noise)} \]

Parameter Content

\( \eta \text{ Noise} = \text{natural AWGN (Additive White Gaussian Noise)} \)

\( \beta, \gamma \) Control parameters

\( Q \) Satisfaction degree against condition

\( m_i \) Media interface type

\( k \) Evaluation value (probability) for each access media "k" on device "j"

(2) Dynamic Clustering Management Model

\[ \frac{dm_i}{dt} = f(m_i) + a + q \]

Best controller domain to join is selected based on the ratio of control signaling to user traffic

\[ \frac{dm_i}{dt} = \max(m_{i-1}, m_{i-2}, ..., m_{i-k}) - m_i \]

\[ s(a) = a \left( \beta \exp \left( \frac{-a}{1 + \sqrt{a}} \right) \right) \]

\[ a = \frac{1}{1 + \exp \left( \frac{-a}{1 + \sqrt{a}} \right)} \]

\( \eta \text{ Noise} = \text{natural AWGN (Additive White Gaussian Noise)} \)

Parameter Content

\( \eta \text{ Noise} = \text{natural AWGN (Additive White Gaussian Noise)} \)

\( \beta, \gamma \) Control parameters

\( Q \) Satisfaction degree against condition

\( m_i \) Media interface type

(2) Dynamic Clustering Management Image

To change clustering dynamically according to the attractor selection equation in order to reduce signaling cost for inter-domain handover

Configuration (Best Radio I/F Selection)

Equation of the Yuragi controller is driven, based on the real-time radio link quality

Selection Algorithm Example

(1) Select new radio interface at random

(2) Store packet transmission statistics

(3) Measure real-time available bandwidth by using packet loss information

(4) Measure real-time available bandwidth by using packet loss information

(5) Select new one of the cost appropriate interfaces

Simulation scenario and parameters

A scenario with sudden degradation of either radio link

Parameter Value

Number of radio interfaces: 2

Spreading code length: 31 chip

Data transmission rate & Chip rate: 1 Mbps & 32 Mcps

Data decision method: Maximum likelihood decision (matched filter)

Carrier frequency: 20 MHz

Transmission line model: Additive White Gaussian Noise

Min. threshold for Eb/No & Bandwidth: 10 dB & 100 Hz
Simulation Model

Data transmission model with Additive White Gaussian Noise and Multipath Rayleigh Fading on a transmission line

Simulation Results (1)

Transition of the selected best radio interface
- To cope with the sudden degradation of radio link quality

Simulation Results (2)

Transition of Bit Error Rate on each radio interface
- The interface to have a better BER is selected

Conclusion

Summary
- Proposed concepts to adapt attractor selection mechanism into future mobile network
  - To select the best radio interface among several interfaces on one mobile node
  - To formulate the best cluster to alleviate signalling cost for inter-domain handover
- Evaluations by simulation
  - Our proposed method can cope with a sudden change of radio link quality in case of the radio I/F selection

Future Work
- More evaluations on different scenarios