

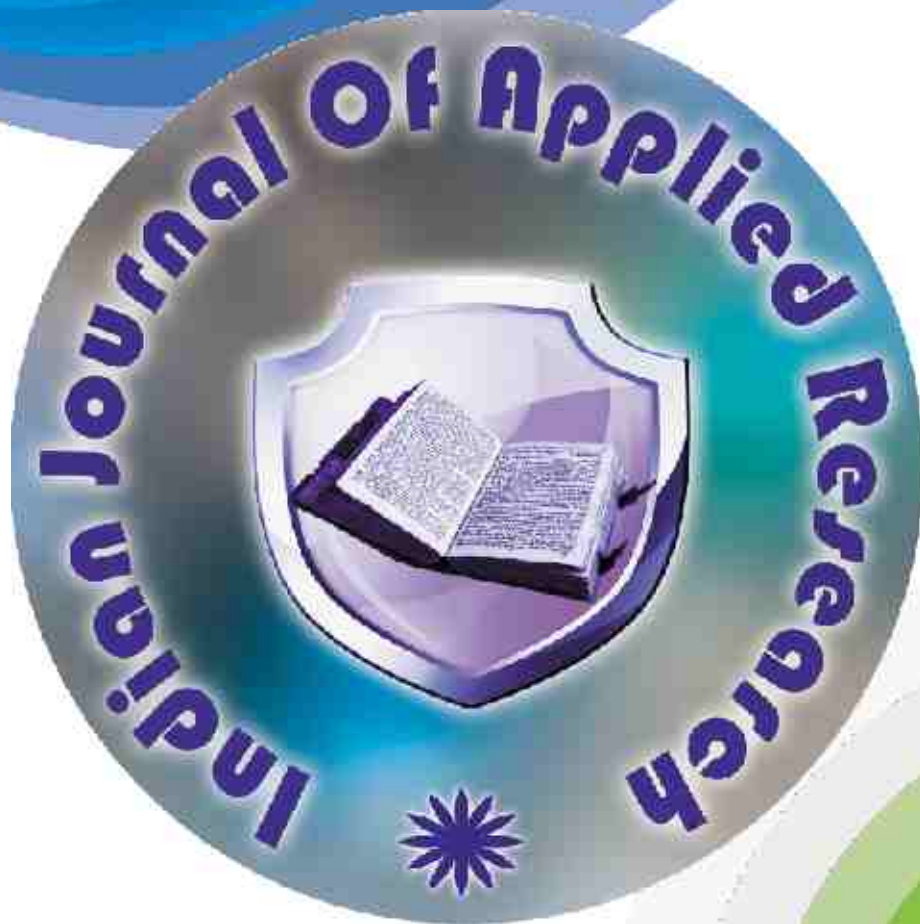
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Index

Sr. No	Title	Author	Subject	Page. No.
1.	Assay Of Triphenylmethane Reductase Enzyme And PCR-Based Identification Of TMR Gene In Enterobacter Asbriae Strain XJUHX-4TM	Tina Mukherjee, Mounita Bhandari, Manas Das	Biotechnology	1-2
2.	An Analysis Of Growth Of Credit Card Industry	Dr. A. Vinayagamoorthy, K. Senthikumar	Commerce	3-5
3.	Impact Of Pre-Merger And Post Merger On Financial Performance (With Reference To Private Sector Banks)	Dr. Shital Vekariya	Commerce	6-8
4.	Relativity On Climate And Competencies In Human Resource Development With Reference To Neyveli Lignite Corporation Ltd,	S. Jayakumar. Dr. R. Ramachandran	Commerce	9-11
5.	Human Resource Outsourcing: A Strategy For Gaining Competitive Advantage	Dr. Santosh M. Singh	Commerce	12-13
6.	Relationship Between EVA And ROI And MVA (A Case Study Of Ten Manufacturing Industries In India)	Dr. Shivani Gupta	Commerce	14-15
7.	Modeling The Traits Of An Effective Teacher At Higher Education	Dr. Haridayal Sharma	Commerce	16-17
8.	Mahatma Gandhi National Rural Employment Guarantee Act (Mgnrega): Issues And Challenges	Dr. Mohd. Ashraf Ali, Mushtaq Ahmad	Commerce	18-20
9.	Standardisation And Grading	Viram. J. Vala, Dr. Vijay Kumar Soni	Commerce	21-22
10.	Profitability Of Selected Information Technology Companies In India	Dr. M. Jegadeeshwaran, C. Udaya	Commerce	23-25
11.	Emerging Trends In The Indian Media And Entertainment Industry	Dr Mahalaxmi Krishnan	Commerce	26-27
12.	Inventory Management Strategies And Control Techniques: An Empirical Investigation Of Small Scale Industries	Vipul Chalotra, Neetu Andotra	Commerce	28-30
13.	A Study On Performance Indicators Of Commercial Banks	Dr. G. Ganesan, P. Parthasarathy	Commerce	31-33
14.	Improved Approaches To Coreference Resolution In Machine Learning	Kuldeep Singh Raghuwanshi, Ashwini Kumar Verma	Computer Science	34-37
15.	Security Issues & Controls In Cloud Computing	V. Naga Lakshmi	Computer Science	38-40
16.	Human Development Index Of De-Notified Nomadic Castes In Maharashtra Division: A Study Of Jalna And Aurangabad Districts	Dr. Ashok Pawar	Economics	41-43
17.	Public Private Partnership In Rural & Urban Projects In India	Dr. Ashok S. Pawar, Dr. Shankar B. Ambhore	Economics	44-45
18.	Populace Insight On Development In Public Health Sector Of India Subsequent To Functioning Of National Rural Health Mission	Krishnakant Sharma	Economics	46-49
19.	Problems Of Rural Women Entrepreneurs In India: A Conceptual Overview	C. Jeyasri Usha N Devi, Dr. A. Sankaran	Economics	50-52
20.	Poverty Of Banjara And Vanjari Communities In India	Tidke Atish S., Dr. Pawar Ashok S.	Economics	53-54
21.	India And China: Economic Reforms And WTO	Dr. Surinder Kumar Singla, Dr. Kulwinder Singh	Economics	55- 56
22.	Implementing Life Skill Education Strategies In Teaching – Learning Process	R. Kalaiselvi, Dr. A. Palanisamy, Dr. A R. Saravanakumar	Education	57-59

23.	Utilisation Of Modern Technology By The Teachers In Pupil Processing Organisation	Dr. P.Paul Devanesan, Dr A. Selvan	Education	60-61
24.	Impact Of Vocational Training On Students	K.Sudha Rani, G.Umapathi, Dr. T. Ananda,	Education	62-63
25.	A Study On Emotional Intelligence Of Secondary School Teachers	Dr. Umme Kulsum, Prathima H.P.	Education	64-66
26.	The Efficiency Of Feedback Strategy Of Homework On The Development Of 10th Grade EFL Writing Skill In Al-Karak Educational Directorate	Majid Al- Khataybeh, Areej Al-Shourafa`	noitacudE	67-74
27.	Perspectives Of Stress Management In Education System	M. Meenakshisundaram, G. P. Raja, Dr. A R. Saravanakumar	Education	75-76
28.	Attention Regulation Of Meditators And Non-Meditators Of Class IX	G. Madhavi Kanakadurga, Dr. D. Vasanta Kumari,	Education	77-78
29.	Role Of Psychoeducation In Teaching – Learning Process	Dr. A R. Saravanakumar, Dr. A. Balu, Dr. S. Subbiah	Education	79-80
30.	Microcontroller Driven RGB Led System For Tristimulus Surface Colorimetry	T. N. Ghorude, A. D. Shaligram	Electronics	81-83
31.	Pmgsy And Rural Roads Development In India: Economic, Financial And Maintenance Issues	K.C. Manjunath	Engineering	84-86
32.	Routing Packets On A Chip.	Naren V Tikare	Engineering	87-89
33.	Finding The Nearest Neighbors In Biological Databases	Er. Pankaj Bhambri, Dr. O.P. Gupta, Er. Franky Goyal	Engineering	90-92
34.	Factors Affecting The Sustainability Of The Asphalt Roads: A Case Study Of Irbid Inner Ring Road, Jordan	Eng. Nasr Ahmad Dr. Mihai Iliescu	Engineering	93-94
35.	Physical And Chemical Testing Of Compounded PVC	Sapna Dabade, Dr. Dheeraj Mandloi, Deepak Khare	Engineering	95-96
36.	Impact Of Organic Farming On Yield Of Some Common Crops- A Case Study.	Namrata D. Awandekar	Environmental Science	97
37.	Hydrogeologic Settings Of The North And South Brahmaputra Plains In Upper Assam: A Comparative Study	Dr. Uttam Goswami	Geology	98-100
38.	To Study Staffing Pattern In Rajasthan Public Healthcare Delivery System.	Dr. Ashwin G. Modi, Sushman Sharma	Healthcare	101-105
39.	Work And Health: A Situational Analysis Of Factory Workers	Dr. S. S. Vijayanchali, Dr. E. Arumuga Gandhi	Home Science	106-108
40.	Performance Of Camel Kid Hair: Acrylic Blended Yarn And Knitted Fabric	Suman Pant, Anjali Sharma	Home Science	109-110
41.	Impact Of Holistic Nutrition Education Package On Diabetes Mellitus Control In Middle Aged Women	Dr. Anjali Rajwade	Home Science	111-112
42.	Assessment Of Relationship Between Ida And Personal Hygiene, Nutritional Knowledge And Dietary Practices In Adolescent Girls	Dr. Anjali Rajwade	Home Science	113-114
43.	Employee Attrition And Retention In Private Insurance Sector– A HRM Challenge	Dr. J. Senthil Vel Murugan, S.Bala Murugan	Human Resource Management	115-117
44.	A Study On Impact Of Unionism On Industrial Relations In Manufacturing Sector	Jaya Ahuja	Industrial Relations	118-120

45.	Augmentation Of India's Foreign Exchange Reserve: An Analysis	Dr.S P.Mathiraj, Ar.Annadurai	International Business	121-123
46.	Films – A Techno Literary Art Form	Dr. Dipti Mehta	Literature	124-125
47.	Indirect Models Of Reading To Develop Descriptive Writing	Dr. K. Madhavi	Literature	126-128
48.	Ramkrishna Mishra Ke Upanaso Me Rajnetaik Chetavni	Dr. Sanjay Rathod, Dilip Jhadav	Literature	129
49.	Hindi Kavita Me Nari Jivan Ka Badla Swarup	Dr. Sanjay Rathod	Literature	130
50.	Impact Of IPL Sponsorship On Consumer Buying Behavior With Reference To Nagpur City	Chandrima Das	Management	131-135
51.	Crowd Sourcing –A New Management Mantra	Devi Premnath, Dr. C. Nateson	Management	136-137
52.	Small Scale Industries In India: An Evaluation Of Productivity In The Post-Liberalized Scenario	Dr. Gaurav Lodha,	Management	138-139
53.	Comparative Analysis Of Milk Products With Respect To Its Competitors With Special Reference To Karnataka Milk Federation (KMF) – At Dharwada City, Karnataka, India	Dr. N. Ramanjaneyalu	Management	140-143
54.	A Study On Work Stress In Women Employees In Coimbatore District	R. Maheswari, N. Brindha	Management	144-145
55.	Accounting For Carbon Credits	Dr. Gaurav Lodha	Management	146-148
56.	A Literature Review On The Relationship Between Training (As A Core Responsibility Of HRM) And Firm Performance.	Priya Sharma, Dr. S. L. Gupta	Management	149-152
57.	A Study On Agricultural Marketing Practices And Constraints With Special Reference To Paddy / Rice.	CM Maran, Dr Raja Pranmalai	Management	153-156
58.	Performance Of Share Price Of Indian Public Sector Banks And Private Sector Banks - Comparative Study	V. Prabakaran, D. Lakshmi Prabha	Management	157-158
59.	Intuitionistic Fuzzy Primary And Semiprimary Ideal	Dr. M.Palanivelrajan, S.Nandakumar	Mathematics	159-160
60.	Significance Of Umbilical Artery Velocimetry In Perinatal Outcome Of Fetuses With Intrauterine Growth Retardation.	Dr G S Shekhawat	Medical Science	161-163
61.	Large Adult Sacrococcygeal Teratoma: A Case Report And Review Of Literature.	Dr.Yavalkar Pa, Dr. Naik Am.	Medical Science	164-165
62.	Epidural Steroid In Low Back Ache	Dr. B. L. Khajotia, Dr. Neelam Meena	Medical Science	166-167
63.	A Comparative Study Of Second Trimester MTP With Use Of Vaginal Misoprostol And Extra Amniotic Instillation Of Ethacridine Lactate.	Dr. Ketaki Junnare, Dr. Sameer Darawade, Dr. Priyamvada Shah, Dr. Swati Mali.	Medical Science	168-169
64.	A Novel Surgical Approach For Treatment Of Sui –TVT Obturator Tape	Dr. Ketaki Junnare, Dr. Durga Karne, Dr Neelesh Risbud.	Medical Science	170-171
65.	Advantage Of Fallopian Tube Sperm Perfusion Over Intra-Uterine Insemination When Used In Combination With Ovarian Stimulation For The Treatment Of Unexplained Infertility.	Dr G S Shekhawat, Dr Pushpalata Naphade	Medical Science	172-175

66.	"Bilateral Sertoli-Leydig Cell Tumor In Postmenopausal Female" A Case Report	Dr. Priyamvada Shah, Dr. Ketakijunnare, Dr. DurgaKarne	Medical Science	176-178
67.	Pretreatment With Ephedrine For Prevention Of Pain Associated With Propofol Injection.	Dr. Kavita U Adate, Dr. Jyoti A. Solanki	Medical Science	179-181
68.	Does The Structured Teaching Programme Influence The Knowledge About Physical Wellbeing Of School Children? A Quasi Experimental Study.	Dr. S. Valliammal, Dr. Ramachandra, Raja Sudhakar	Nursing	182-184
69.	An Approach For Information Retrieval For Bookstores Using Formal Ontology	Sumit Jain, C.S.Bhatia	Ontology	185-187
70.	Analgesic Activity Of Anacardium Occidentale	A. Devadoss, C. Aparna, K. Parimala, D. Sukumar	Organic Chemistry	188-190
71.	Behaviourism : Science Or Metaphysics	Dr. Jatinder Kumar Sharma	Philosophy	191-193
72.	Multi-Dimensional Perspectives Of Obesity And Its Management	S. Dhanaraj, Dr. A. Palanisamy	Physical Education	194-196
73.	Refractive Index, Density, Excess Molar Volume, Excess Molar Refraction For Liquid Mixtures (Ethyl Ethanoate + Benzene Derivatives) At Different Temperatures	Sheeraz Akbar, Mahendra Kumar	Physics	197-199
74.	Refractive Indices, Densities And Excess Properties For Liquid Mixtures (Cetane + Alkanols) At Different Temperatures	Sheeraz Akbar, Mahendra Kumar	Physics	200-202
75.	Capacity Building For Effective Local Governance: Indian Perspectives	Dr. Pralhad Chengte	Political Science	203-205
76.	Psychological Well-Being: A Study Of Non-Institutionalized Aged	Dr. Pankaj S. Suvera	Psychology	206-208
77.	Women Empowerment Through N R E G S (With Reference To State Of West Bengal)	Dilip Kumar Karak	Social Sciences	209-211
78.	Effect Of Selected Yogic, Aerobic And Laughter Exercises On Blood Pressure Of High School Boys	Dr.Manjappa.P, Dr.Shivarama Reddy. M	Sports	212-216
79.	Association Study Between Lead And Copper Accumulation At Different Physiological Systems Of Goat By Application Of Canonical Correlation And Canonical Correspondence Analyses	Partha Karmakar, Debasis Mazumdar, Seema Sarkar (Mondal), Sougata Karmakar	Statistics	217-219
80.	Development Of Silver -Silica Nanocomposite For Novel Humidity Sensing Application	Surender Duhan	Technology	220-221



Routing Packets On A Chip : Network On Chip Algorithm

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ABSTRACT

In this paper, static method of routing packets is proposed for a Network-on-chip. Network-on-chip is a collection of several nodes connected together in a closed loop. Every node in the Network-on-chip has its unique addresses which help to establish communication between desired intellectual properties. In order to prevail static routing, all the nodes in the Network-on-chip consists of a CAM routing table. The table holds the addresses of all the nodes in the Network-on-Chip. The connection is established by a special packet called route establishing packet. This packet holds the addresses of the source and destination nodes. As this packet traverses through various nodes, it links these two addresses in the routing table by a unique binary nibble. The data packet compares its nibble with the nibble in every node to which the source and destination address is linked. The node in turn will provide information about the destination of the packet. Hence, at the end of data transfer, route destruction packet delinks the two addresses in the routing table.

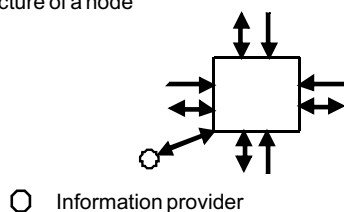
Keywords : Network, on chip networking, static routing, Network on chip.

Introduction

Network-on-chip is an emerging paradigm for communication, built on chip, for complex System-on-Chip architectures. It uses packet-switching for communication allowing integration of a large number of computational, processing as well as storage blocks on a single chip. Network-on-Chips are aimed to provide enhanced performance, modularity, design productivity when compared to traditional communication architectures such as dedicated signal wires and bus architectures. In order to manage the vast number of transistors on chip, we will have to make use of some new technology arrangement, and for this virtue, SoC and NoC are the two main implementation approaches (Micheli, 2006). Presently, portable computers and cell phones and numerous products all implemented on a silicon chip (Smith) are all lively examples of SoC architectures. Due to ever increasing number of transistors (Smith) they will have a complex design and also long time to market as described in (L. Benini, 2007), (Widjaja, 2001), and (Benini, 2004). NoC provides efficient communication (The 2nd IEEE International Symposium on Networks-on-Chip, 2008) between all the cores in a SoC as in (L. Benini, 2007), (Widjaja, 2001), (Benini, 2004). The communication takes place by the help of packets where every packet takes a specific route within NoC for efficient communication between two IP's as discussed in (Special issue on networks on chip, 2004).

Architecture

Fig 1. Structure of a node



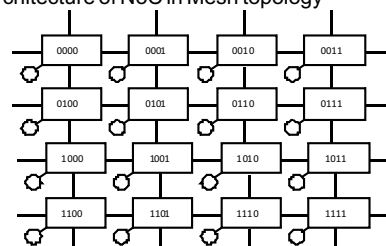
This is a simple node architecture as in (Special issue on networks on chip, 2004) which consists of

1. Bi-Directional buses
2. Control signals
3. Information provider (IPr)

All packets used in the network are 16 bit in size and are not variable in length. This allows the busses to be of 16 bits size and parallel bus architecture is faster and more reliable. The control signals used in this design help in proper communication between nodes, before and after packet transfer. The two control signals used are Request and Enable and are 1 bit in size. The control signals along with the busses are connected from every node to its neighboring node in all the directions.

Control signals used are hand shake signals which help in reducing traffic of packets in the network. Whenever a packet wants to travel from its current node, it requests for the availability resources to the next node to which it is to hop. If the node is not handling any other packet transfer, it acknowledges by Enable signal and thus the packet can initiate its move to the next node. Till the time, a packet is in a node, the node does not perform any other function other than processing the current packet and forwarding it to the next node. Once the processing is complete, and all resources are free, it is when it handles the next packet.

Fig 2. Architecture of NoC in Mesh topology



Methodology

NoC is a collection of several nodes connected together, as per design requirements and the efficiency of communication necessary. There are various different types of topologies, used for connecting the nodes in the NoC.

- Mesh (J. Duato, 2002)
- Torus (W.J. Dally C. S., 1986), Star (Micheli, 2006)
- Octagon (S. B. Akers, 1989)
- SPIN (Adriahantenaina, 2003)

Every node in the NoC consists of a bidirectional data bus for the flow of packets in and out of the node, control bus for handshaking between two nodes, placed at the outer jacket of the node. Every node is connected to the other node by these data busses and control signals. Every node connected, is given a unique address for its identity. The address may start from 0000 to 1111 for a combination of 24 nodes and from 00000000 to 11111111 for a combination of 28 nodes. There is a complex internal architecture in a node, consisting of a CAM routing table, and a buffer. CAM table consist of information like the addresses of all nodes in a NoC, with some free space to add some Additional Information (AI).

To initiate, an IP forwards a packet to the node connected to it in a NoC, hence, the packet hops across various nodes, till it reaches its destination IP. For subsequent routing of packets in the NoC, 3 types of packets have been introduced. They are:

- Route establishment packet (REP).
- Data packet (DP).
- Route destruction packet (RDP).

Firstly, REP is introduced into the network where it consists of just the payload and no header. Payload consists of

- Source and destination IP addresses.
- AI (nibble).
- Information about the number of hops (decrement counter).
- Direction bits provide information regarding the route within the network to reach the destination.

Fig 3. Route Establishing Packet

Direction bits	Number of hops	AI	Source and destination addresses
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Suppose there is a need for data transfer between any two IP's, the source IP introduces a REP in to the network through the data bus connected between it and its corresponding node. The address of source and destination in REP is compared with that of CAM table. Once the addresses are found, they are locked together with a combination of 4 bits called AI. Once the packet is hopped from one node to another, the direction bits are shifted two bits left and hop bits are decremented by two. Hence, the remaining direction and hop bits are stored in the corresponding memory relating to AI. Direction bits provide information regarding the next node to be hopped in the network. Every move of the packet corresponds to two direction bits.

If 00= packet is moved left

01=packet is moved straight

10=packet is moved right

11=packet is returned to its previous node.

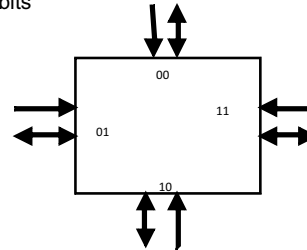
Hop bits are used as a down counter which is initialized at the beginning and reset to zero when the packet reaches its destination.

Thus in every node where REP flows, it leaves behind information regarding the destination address, number of hops and the path necessary for the forthcoming DP to track its destination.

The packet following REP is DP; it has a very small header and a large payload. The header just consists of

- AI (nibble)
- Data information.

Fig 4. Example showing forwarding of packets with respect to direction bits



As REP has already provided information to various nodes about the destination of the packet, DP just has to verify its AI with that of the information in the CAM, and it provides information about the destination, information of the next node and the number of hops needed by DP to the destination. Accordingly, DP is introduced by the source IP with just four bits of information and data.

Fig 5. Data Packet

Data	AI
------	----

When there are no more data packets to be transmitted from that particular source IP to the destination IP, the locked addresses in the CAM of a few selected nodes can be unlocked by the aid of transmitting a RDP from the source IP to destination IP, by transmitting it through the same nodes via which REP and DP were transmitted in prior. RDP consists of even less information when compared to REP and DP. The need of source and destination address is not necessary when transmitting RDP. Rather it may include the last bits of data as that of data packet in the payload and AI and number of hops in the header of RDP. When RDP enters the first node, it gathers information of the next node and deletes AI and its associated information about direction and the number of hops in the node. As it reaches the destination IP, it conveys the last packet of data and thus frees all locked nodes in the NoC for future communication.

Fig 6. Route Destruction Packet

Data bits	Zero bits	AI
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Tools/ Implementation

The design of NoC is carried out in a software tool named Xilinx version 13.2. The simulation results have all been observed in simulation software called Modelsim. Firstly, the design is tested with various test benches, with at least more than thousand sets of input data. Input data corresponds to the three types of packets where the bits in the packet have been manually entered in the test bench as inputs, then the program is compiled and the corresponding simulation result is been observed. Once the design is working efficiently, it is then implemented in an FPGA, named Spartan 3. The design is well sophisticated with 980000 gates approximately. The specifications of the FPGA are given in (<http://uk.farnell.com/xilinx/xc3s1500-4fgg456c/fpga-spartan-3-1-5m-gates-456fpga/dp/1762476>).

Conclusions

NoCs are the emerging network solutions for SoC designs and have also tackled many disadvantages of SoCs. The design described in this paper focuses on the algorithm to route packets in the network by static means. It deeply discusses static methods to transfer packets between different IPs. The concept is well described by using 3 different types of packets namely REP, DP and RDP. Every IP connected to the NoC is given a unique address, which is saved in CAM routing table of all the nodes in NoC. When there is a need for data transfer from an IP to another IP connected to the same NoC, the source IP introduces REP in to the network, followed by DP; when the data is fully transmitted, source IP sends RDP and the connection between source IP and destination IP is erased.

There is a possibility that one NoC can be connected to another NoC; only if the design considerations such as bus width, control signals match each other.

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