

Diamond流表设计

1. 流表顺序与必要性讨论

参考软交换机流表，考虑到板卡实际处理逻辑，流表映射对比如下：

软交换机流表	板卡流表	原因	序号
以太表	无	Parser处理	
IPv4表	无	Parser处理	
IPv6表	Local表	这张表会判断目的地址在不在本节点上，形成Packet状态供后续（组播、增强传输）表使用。表项上有Counter，用于下行流量统计。	0
高可靠传输收侧表	高可靠传输收侧表		1
UDP表	无	Parser处理	
IRA匹配表	Dispatch分发表	TCAM匹配IRA、SEAID.type、Inport端口类型、Cache Hop	2
隐匿表	隐匿表		3
缓存表	无	合并到了 Dispatch分发表	
组播数据表	组播Flow表	软交换机在指令块里进行了数据包复制和字段修改；而板卡独立出了复制引擎，分解了组播查找、复制和修改字段动作	4
	复制引擎		5
组播复制转发表	组播Packet修改索引表		6
	组播Packet修改表		7
多路径传输表	多路径传输表		8
OFIB1	OFIB1		9

OFIB2	OFIB2		10
OFIB3	OFIB3		11
INT表	无	小节点不支持带内遥测	
线路选择表	源地址表	用于修改源地址，位于OFIB与FIB之间。	12
FIBv6	FIB HOST	拆成了三张表	13
	FIB LPM		14
	邻接表		15
FIBv4	无	Parser处理，直通	
ID解析表	ID解析表		16
高可靠传输发侧表	高可靠传输发侧表		17

2. 流表规格

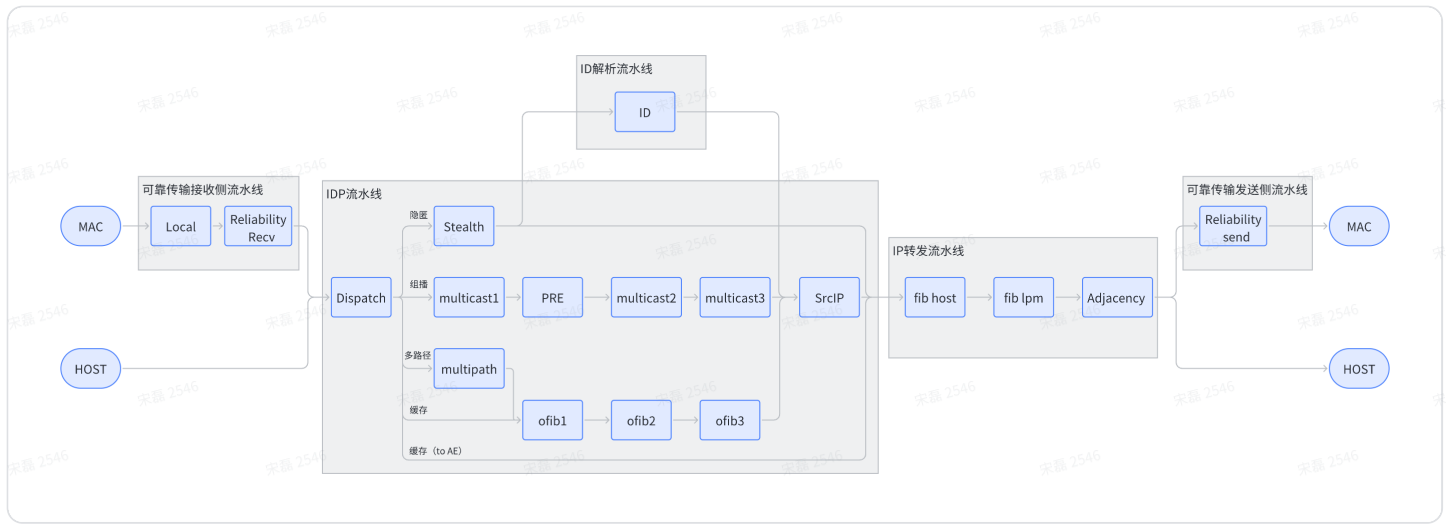
最终Diamond迭代包含的流表规格如下

流表序号	流表名称	流表类型	流表深度	说明
可靠传输接收侧流水线				
0	Local表	EM HASH	128	HASH表实现时深度翻倍； 每条表项有FlowState，用来作为Counter统计下行流量；
1	高可靠传输收侧表	EM HASH	1024	HASH表实现时深度翻倍； 每条表项有FlowState，用来标识接收侧流预期的RPN号；
IDP流水线				
2	Dispatch分发表	MM TCAM	32	
3	隐匿表	Group	128	
4	组播Flow表	EM HASH	1024/4096	HASH表实现时深度翻倍
5	复制引擎	Linear	1024/4096	
6	组播Packet修改索引表	Linear	2048/8192	

7	组播Packet修改表	Linear	1024	
8	多路径传输表	EM CAM	256	表上有TableState，包含8个路径的ServType号码以及权重； 每条表项有FlowState，包含当前Index、每个路径的当前权重和nextServType；
9	OFIB表1	EM HASH	1024	HASH表实现时深度翻倍
10	OFIB表2	Linear	8192	表上有TableState，包含8个路径的ServType号码
11	OFIB表3	Linear	1024	
12	源地址表	Linear	128	每条表项有FlowState，用来作为Counter统计上行流量；
IP转发流水线				
13	FIB HOST	EM HASH	1024	HASH表实现时深度翻倍
14	FIB LPM	LPM TCAM	16	
15	邻接表	Linear	1024	
ID解析流水线				
16	ID解析表	EM HASH	2M/8M	存储在片上DDR中
可靠传输发送侧流水线				
17	高可靠传输发侧表	EM HASH	1024	HASH表实现时深度翻倍； 每条表项有FlowState，用来标识发送侧流预期的RPN号；

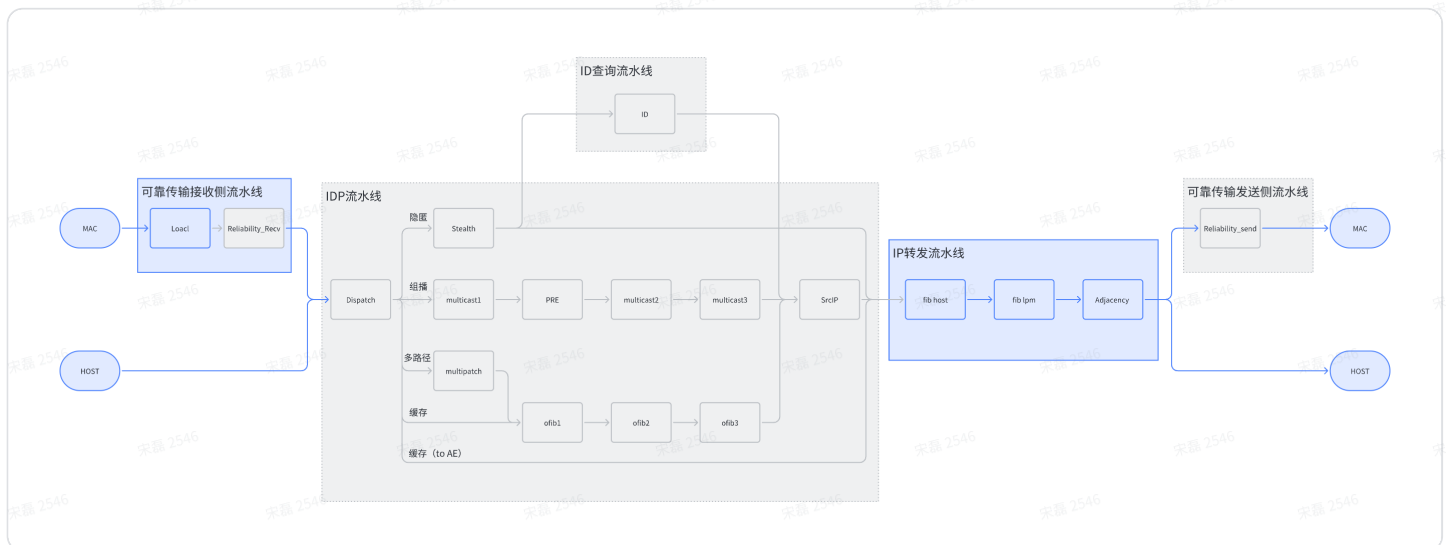
3. 流表跳转图

1. 总图



2. 各类网络数据报文处理示意

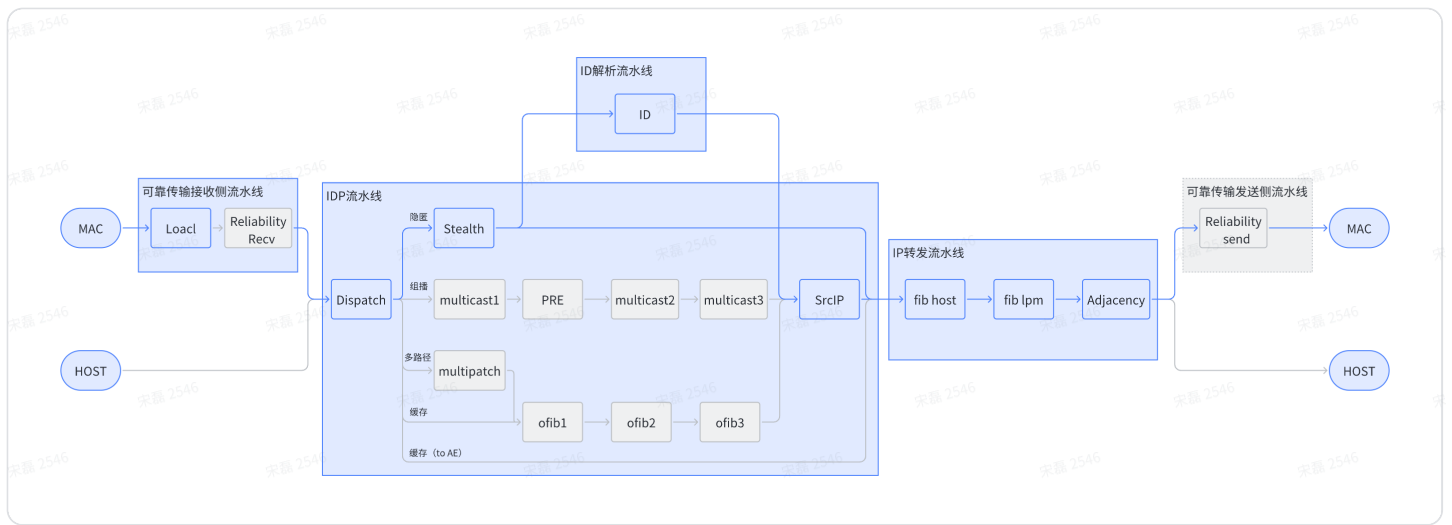
3.1 非IDP报文



IDP流水线的Parser解析数据包的各层协议类型，非IDP数据包会跳过IDP流水线MAU的处理，交给IP转发流水线执行路由转发：

- 如果该报文是ipv6数据报文，则根据报文中的ipv6目的地址在fib表中查询报文输出的端口并进行修改mac地址、vlan头部等操作；
- 如果该报文不是ipv6数据报文，则根据报文输入端口决定输出端口，不进行报文内容的修改（转发模式）；
- 特别地，对于IPv6 NS报文则会在IP转发流水线的parser处直接pktin

3.2 IDP隐匿报文



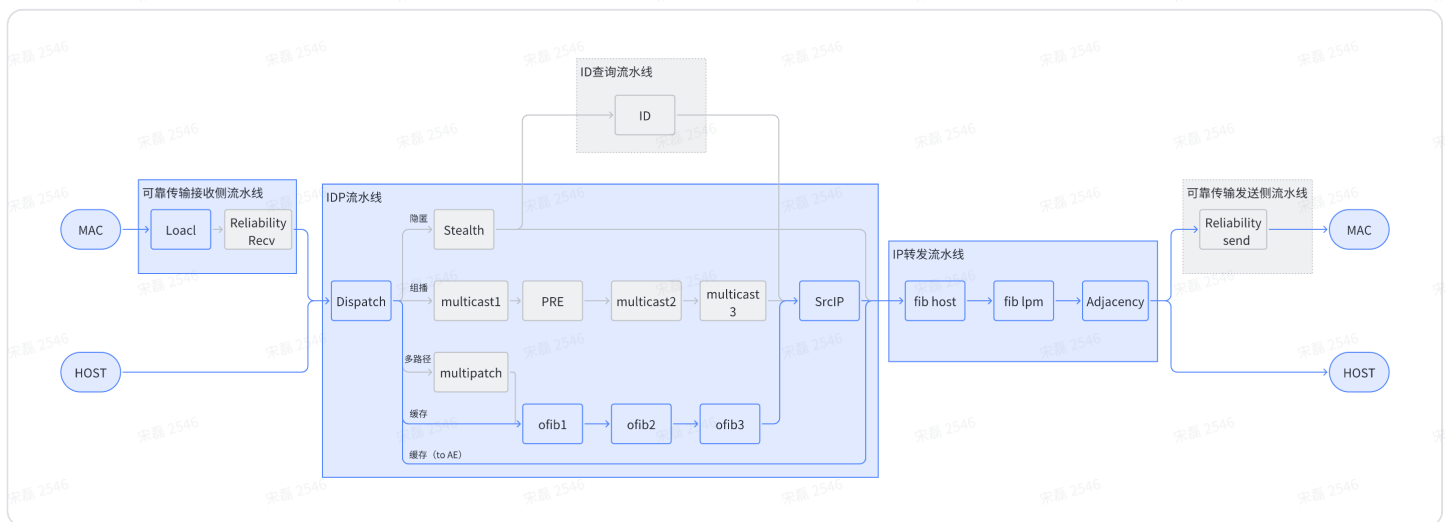
IDP隐匿报文由IDP流水线中的隐匿MAU以及ID查询流水线处理：

当IDP隐匿报文中的跳数为0时，该报文会前往ID查询流水线查询dst_ID获取对应的dstIP以及需要修改的srcIP（在srcIP修改表中的地址），随后回到IDP流水线修改srcIP，并在ip转发流水线中根据获得的dstIP查询转出端口；

而当IDP隐匿报文中的跳数不为0时，则会在隐匿MAU中随机选择下一跳节点（称为随机游走），并根据获得的下一跳节点地址在ip转发流水线中查询转出端口；

同时当IDP隐匿报文中的跳数不为0时，也有可能一定几率前往ID查询流水线（称为直接转发），报文在隐匿MAU随机游走与直接转发的实现是通过使用以时间戳作为随机种子的随机选择实现的。

3.3 IDP缓存报文



IDP缓存报文由IDP流水线中的Dispatch MAU处理：

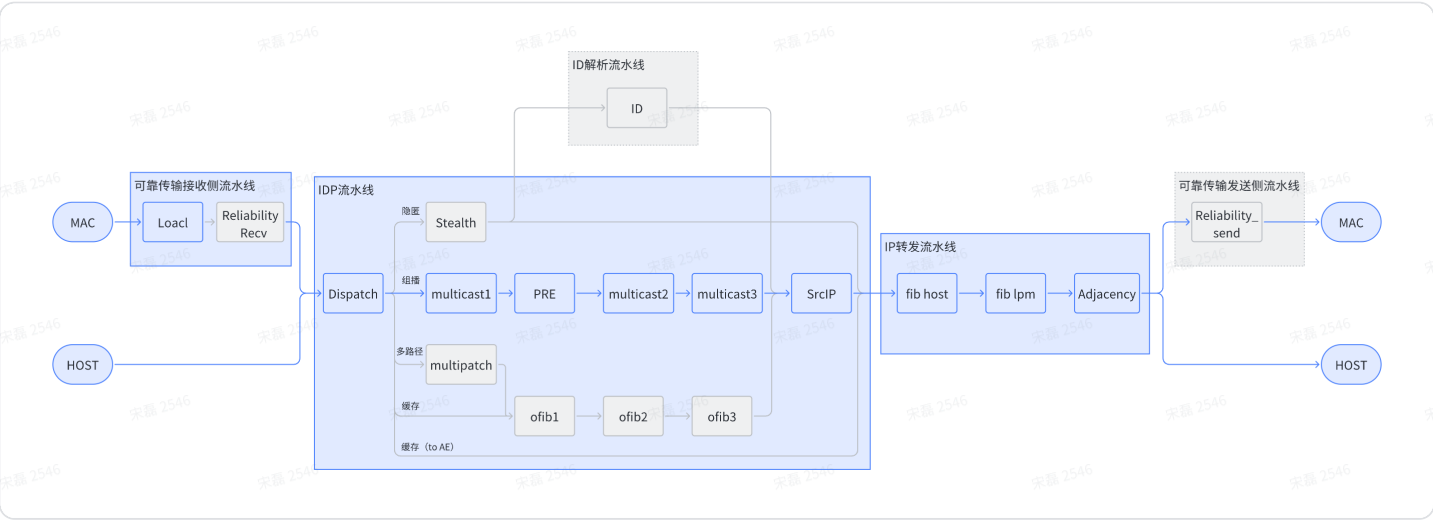
来自HOST的缓存请求，通过OFIB发出；

来自MAC的缓存请求，转给AE（通过HOST）；

跳数不为0的缓存数据，跳数减一并通过OFIB发出；

跳数为0的缓存数据，转给AE（通过HOST）。

3.4 IDP组播报文

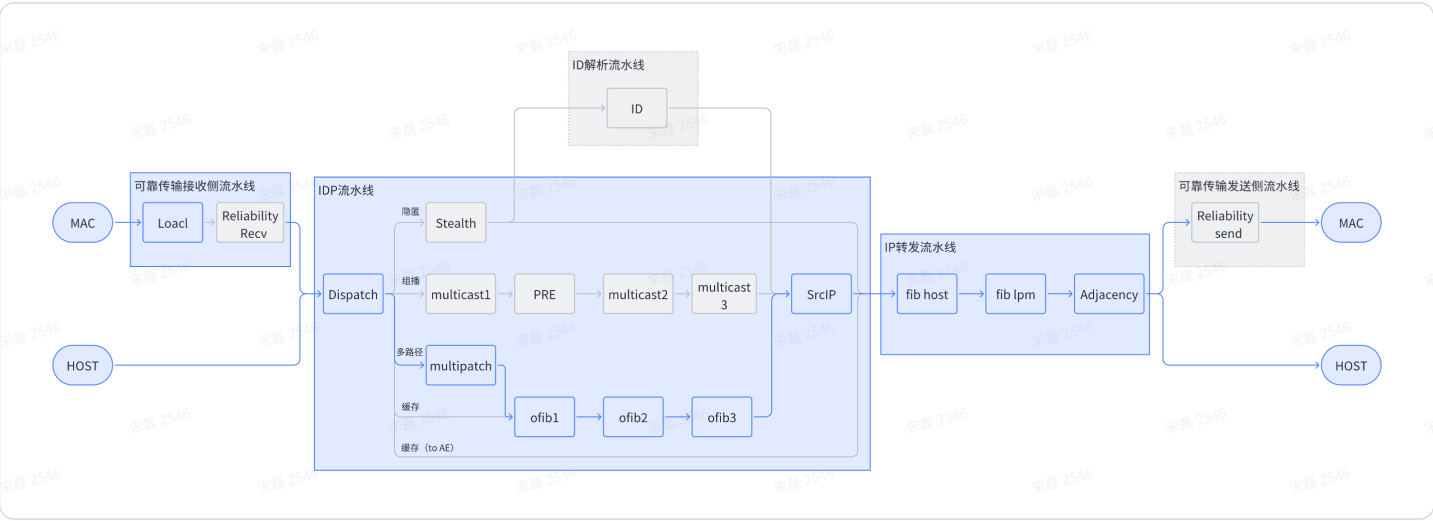


组播数据报文的处理由组播1、2、3 MAU以及复制引擎实现：

- a. 组播表1通过id获得报文在复制引擎中对应的索引
- b. 复制引擎根据索引将报文复制，并给每个复制报文提供连续的索引以及在组播表2中的偏移
- c. 组播表2则根据偏移和索引获得组播表3的索引，该索引可以不连续以实现在不同组播流中的自由复用相同的报文数据操作
- d. 组播表3根据索引实现对报文目的地址的修改，同时指示源地址修改表的索引
- e. 最终报文在源地址修改表中完成源地址的修改，前往ip转发流水线完成处理流程

组播控制报文的处理，由IDP流水线将发往local地址的SCMP报文PKTIN给控制器，控制器通过PKTOUT发出控制报文；不是发往local的控制报文交给IP转发流水线转发。

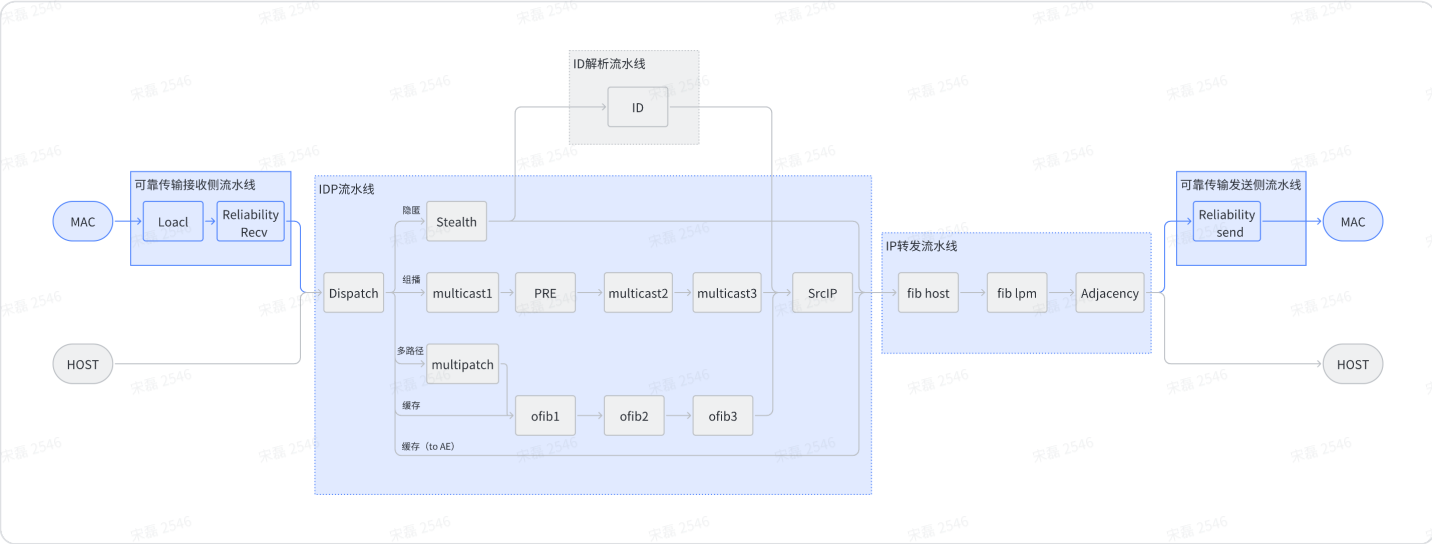
3.5 IDP多路径报文



IDP多路径报文由IDP流水线中的多路径 MAU处理：

根据报文中的mpt与表状态中的mask确定报文可以选择的拓扑，随后进入流表匹配获得根据权重计算得到选择的拓扑。

3.6 高可靠传输报文



高可靠增强传输相关逻辑由高可靠发送侧流水线以及接收侧流水线处理，而在IDP流水线中按照普通IDP报文处理，具体的：

- a. 接收侧DAT丢包检测：在Reliability_Recv表中比较Pkt.RPN和Flow.RPN，当Pkt.RPN > Flow.RPN时检测到DAT有丢包，触发接收侧发NACK。
- b. 接收侧发起NACK：在高可靠增强传输接收侧流水线出口，通过NACK报文发生器按需构造向上游的NACK报文。
- c. 发送侧DAT发送：在Reliability_Send表中用当前Flow.RPN设置Pkt.RPN，DAT报文除正常发出之外，同时产出一份DAT报文交给可靠发送缓存模块缓存。
- d. 发送侧重传：来自网口的NACK报文会一直透到Reliability_Send表进行处理，在此颠倒点到点源目的IP进行匹配，将匹配到的表项号随NACK包一并交给可靠发送缓存模块，可靠发送缓存模块取出缓存的数据包发回到流水线，直接跳转到Reliability_Send表再次发送。

4. 流表设计

0.Local 表

Local MAU（EM，HASH，128 entries） 每条表项上需要Counter（uint64）				
Field	Bits	Maskable	Optional	Description
Dst IP	128	No	No	

				目的IP地址。用于判定数据包目的地址是不是本节点。
ActionData	Bits	Area		Description
LocalType	1	[0]		
NextTable	5	[5:1]		
FlowState	Bits	Area		Description
BytesCounter	64	[63:0]		某端口的SEANet包统计，可通过FlowReq查到

示例表项	动作	说明
7001::0001	Set Local 1 BytesCounter += PktLen If 高可靠valid Set IPIndex Goto Reliability_Recv Table Else Goto Dispatch Table	是自己 数据包先看是不是高可靠 传输
(Default)	Set Local 0 Goto Dispatch Table	

1.高可靠传输收侧表

Reliability_Recv MAU （EM, HASH, 状态可编程，1024）				
Field	Bits	Maskable	Optional	Description
RSIP	128	No	No	SEANet传输层的RSIP。
DstIP	128	No	No	目的IP地址

ActionData	Bits	Area	Description
-	-	-	-
FlowState	Bits	Area	Description
RPN	32	[31:0]	预期接收的RPN

示例表项	动作	说明
(7001::0001) (255)	If NACK Set Output Mac Goto Reliability_Send Else If pkt.RPN < flow.RPN Goto Dispatch Table Else if pkt.RPN == flow.RPN flow.RPN++ Goto Dispatch Table Else Set DropStartRPN flow.RPN Set DropEndRPN pkt.RPN-1 flow.RPN = pkt.RPN+1 Goto Dispatch Table	本质上做的是链路层工作，应在网络层处理之前。 当出现pkt.RPN > flow.RPN时， <u>在接收侧流水线Deparser制造NACK。</u>
(Default)	PKTIN	以前是Goto Dispatch Table，经过与韩锐讨论，现阶段改为PKTIN

2.Dispatch分发表

Dispatch MAU （TCAM， 32 entries）				
Field	Bits	Maskable	Optional	Description
nextHeader	8	Yes	No	IPv6首个Nextheader（暂未使用）
IRA	8	Yes	No	IDP的IRA字段。
SEAID.type	8	Yes	No	IDP的SEAID.type字段，注意这里合并了两个type字段，并注意顺序。 在分离组播流量、判断缓存流量类型时被用到。
CacheHop	4	Yes	No	IDP的IRA参数3。是一个递减的跳数值，用于确认缓存包是否执行随路缓存操作。
Inport.type	2	Yes	No	入端口类型。 type[1:0]=01标识host端 type[1:0]=10标识mac端 type[1:0]=11标识其他端口，如pktout
Local	1	Yes	No	是不是发给本机的包
ActionData	Bits	Area		Description
NextTable	5	[4:0]		
action	3	[7:5]		000表示cache send to AE； 001 表示goto table； 010表示 goto OFIB1，同时hop - 1; 011表示PKTIN

示例表项	动作	说明
(0x80,0xff)(0x00,0x00)(0x0,0x0)(0x0,0x0)	Goto Stealth Table	隐匿 001
(0x40,0xff)(0x00,0x00)(0x0,0x0)(0x0,0x0)	Goto Multipath Table	多路径 001
(0x20,0xff)(0x10,0xff)(0x0,0x0)(0x2,0xf)	Set Outport.type HOST (toAE)	缓存请求 000
(0x20,0xff)(0x10,0xff)(0x0,0x0)(0x1,0xf)	Goto OFIB1	缓存请求 001
(0x20,0xff)(0x01,0xff)(0x0,0xf)(0x0,0x0)	Set Outport.type HOST (toAE)	缓存数据 000

(0x20,0xff)(0x01,0xff)(0x0,0x0)(0x0,0x0)	Cache HOP -1 Goto OFIB1	缓存数据 010
(0x00,0x00)(0x21,0xff)(0x0,0x0)(0x0,0x0)	Goto Multicast1 Table	组播 001
(Default)	PKTIN	PKTIN 011

3.隐匿表

Stealth MAU （Group，Random Select，128 entries）				
Field	Bits	Maskable	Optional	Description
-	-	-	-	-
ActionData	Bits	Area		Description
DstIP	128	[127:0]		
BaseAddr	8	[135:128]		此处为SrcAddr 的BaseAddr
NextTable	5	[140:136]		
action	1	141		0：随机游走； 1：最后一跳

示例表项	动作	说明
	TTL-1 Set DstIP Set ModifySrcIP valid Goto SrcAddr Table BaseAddr	随机游走
	Set TTL 0 Goto ID Table	最后一跳

(Default)	PKTIN
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4.组播Flow表

Multicast1 MAU (EM, HASH, 4096 entries / 1024 entries for DPSS-200)				
Field	Bits	Maskable	Optional	Description
Dst ID	160	No	No	目的ID。
ActionData	Bits	Area		Description
PREID	16	[15:0]		复制引擎ID
NextTable	5	[20:16]		设置 Multicast2

示例表项	动作	说明
0xffeeddccbbaa99887766554433221100000000	Set PREID 0 Set PRE valid, Goto Multicast2	匹配组播数据包的组播服务ID
(Default)	PKTIN	

5.复制引擎

PRE MAU (Linear, Select by BaseAddr (PRE indentifier) , 4096 entries / 1024 entries for DPSS-200)				
Field	Bits	Maskable	Optional	Description
-	-	-	-	-
ActionData	Bits	Area		Description

Replicate Count	8	[7:0]		复制份数
BaseAddr	16	[23:8]		此处为Multicast2的BaseAddr

示例表项	动作	说明
	Replicate Count Set BaseAddr	复制Count份，并为每一份设置Index，从Count-1到0
(Default)	PKTIN	

6.组播Packet修改索引表

Multicast2 MAU（Linear，Select by BaseAddr+PRE Index，8192 entries / 2048 entries for DPSS-200）				
Field	Bits	Maskable	Optional	Description
-	-	-	-	-
ActionData	Bits	Area		Description
BaseAddr	16	[15:0]		Multicast3的base addr
NextTable	5	[20:16]		均为Multicast3

示例表项	动作	说明
	Goto Multicast3 Table BaseAddr	组播包需要逐跳改源IP
(Default)	PKTIN	

7.组播Packet修改表

Multicast3 MAU（Linear，Select by BaseAddr，1024）				

Field	Bits	Maskable	Optional	Description
-	-	-	-	-
ActionData	Bits	Area		Description
DstIP	128	[127:0]		
BaseAddr	8	[135:128]		SrcAddr的base addr
NextTable	5	[140:136]		均为SrcAddr

示例表项	动作	说明
	Set DstIP Set ModifySrcIP valid Goto SrcAddr Table BaseAddr	组播包需要逐跳改源IP
(Default)	PKTIN	

8.多路径传输表

Multipath MAU （EM，CAM 状态可编程，256）				
Field	Bits	Maskable	Optional	Description
MPT&Mask	8	No	No	IDP的MPT字段（OptionA的前8bit），与本节点所在的路径Mask取&
ActionData	Bits	Area		Description
DIV_move_count	2	[1:0]		一般为可选路径数量以2为底的对数取整
NextTable	5	[6:2]		均为OFIB1

Table Status	Bits	Count		Description
SrvType	8	8		8个可选路径的srvType号码
Init Weight	8	8		8个路径的初始权重，0代表路径无效
FlowState	Bits	Area		Description
CurrentWeight	8*8	[63:0]		8组WRR的链表。链表节点当前权重
NextIndex	8*8	[127:64]		8组WRR的链表，链表下一跳index
CurrentIndex	8	[135:128]		当前所选路径

示例表项	动作	说明
0x03	DIV >> 1 (WRR) Set SrvType Goto OFIB1	
(Default)	Goto OFIB1	

9.OFIB1

OFIB1 MAU （EM, HASH, 1024）				
Field	Bits	Maskable	Optional	Description
Ext Addr	128	No	No	IDP的Ext Addr字段。
ActionData	Bits	Area		Description
BaseAddr	16	[15:0]		OFIB2的BaseAddr
NextTable	5	[20:16]		均为OFIB2

示例表项	动作	说明
2001::500	Goto OFIB2 BaseAddr 0	
(Default)	PKTIN	

10.OFIB2

OFIB2 MAU （Linear， Select by BaseAddr+offset(match table status), 8192)				
Field	Bits	Maskable	Optional	Description
-	-	-	-	-
ActionData	Bits	Area		Description
BaseAddr	16	[15:0]		OFIB3的BaseAddr
NextTable	5	[20:16]		均为OFIB3
Table Status	Bits	Count		Description
SrvType	8	8		8个可选路径的srvType号码

示例表项	动作	说明
	Goto OFIB3 BaseAddr 0	
(Default)	Goto OFIB3 BaseAddr LastOne	实现一个默认OFIB路由

11.OFIB3

OFIB3 MAU （Linear， Select by BaseAddr， 1024）				
Field	Bits	Maskable	Optional	Description
-	-	-	-	-
ActionData	Bits	Area		Description
DstIP	128	[127:0]		
BaseAddr	8	[135:128]		SrcAddr 的BaseAddr
NextTable	5	[140:136]		均为SrcAddr
action	1	141		0: 标准SEAWAN的OFIB动作; 1: 逐跳改SrcIP

示例表项	动作	说明
	Set DstIP Set ModifySrcIP invalid Goto SrcAddr Table	标准SEAWAN的OFIB动作
	Set DstIP Set ModifySrcIP valid Goto SrcAddr Table BaseAddr	如果要逐跳改SrcIP，则设置SrcAddr valid
(Default)	PKTIN	

12.源地址表

SrcAddr MAU （Linear， Select by BaseAddr， 128） 每条表项上需要有Counter（uint64）				
Field	Bits	Maskable	Optional	Description
-	-	-	-	-

ActionData	Bits	Area	Description
SrcIP	128	[127:0]	
BaseAddr	8	[135:128]	
NextTable	5	[140:136]	
FlowState	Bits	Area	Description
BytesCounter	64	[63:0]	每个地址的发送流量，可通过FlowReq获取

示例表项	动作	说明
	BytesCounter += PktLen If 可靠传输DAT & local Set RSIP If 源IP修改 Set SrcIP Goto Adjacency Table Else Goto FIB_HOST	
(Default)	Goto FIB_HOST	默认不改SrcIP

13.FIB HOST

FIB_HOST MAU (EM, HASH, 1024)			
Field	Bits		Description

		Maskable	Optional	
DstIP	128	No	No	目的IP地址。
ActionData	Bits	Area		Description
BaseAddr	16	[15:0]		
NextTable	5	[20:16]		

示例表项	动作	说明
	Goto Adjacency Table BaseAddr	
(Default)	Goto FIB_LPM	查不到则去FIB_LPM

14.FIB LPM

FIB_LPM MAU （TCAM， LPM， 16）				
Field	Bits	Maskable	Optional	Description
DstIP	128	Yes	No	目的IP地址。
ActionData	Bits	Area		Description
BaseAddr	16	[15:0]		
NextTable	5	[20:16]		

示例表项	动作	说明
	Goto Adjacency Table BaseAddr	
(Default)	PKTIN	

15.邻接表

Adjacency MAU （Linear, Select by BaseAddr, 1024 entries）				
Field	Bits	Maskable	Optional	Description
-	-	-	-	-
ActionData	Bits	Area		Description
OutPort	8	[7:0]		
DstMAC	48	[55:8]		
SrcMAC	48	[103:56]		
PppoeSessionID	16	[119:104]		
VlanID	12	[131:120]		
PPPoESessionIDValid	1	[132]		
VlanIDValid	1	[133]		

示例表项	动作	说明
	Set DstMAC	
	Set SrcMAC	
	TTL-1	
	If Vlan valid	
	Set VlanID	
	Set Output Port	
	If SessionID valid	

	Set SessionID	
(Default)	PKTIN	

16.ID解析表

ID MAU （EM，HASH，8M）				
Field	Bits	Maskabl e	Option al	Description
Dst ID	160	No	No	目的ID。
ActionData	Bits	Area		Description
NACount	3	[2:0]		
Mode	3	[5:3]		
DstIP	128*6	[773:6]		
BaseAddr	8	[781:774]		
NextTable	5	[786:782]		均为 SrcAddr

示例表项	动作	说明
	Set DsIP Set ModifySrcIP valid Goto SrcAddr Table BaseAddr	隐匿查询完后，造好边带 信号通过PKTOUT回到主 流水线
(Default)	PKTIN	

17.高可靠传输发侧表

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Reliability_Send MAU (EM, HASH, 状态可编程, 1024) 应在多队列模块之后				
Field	Bits	Maskable	Optional	Description
RSIP	128	No	No	SEANet传输层的RSIP。
DstIP	128	No	No	目的IP地址。
FlowState	Bits	Area		Description
RPN	32	[31:0]		流的RPN，用于修改包的RPN

示例表项	动作	说明
(7001::0001) (7001::0002)	If DAT <div> Set pkt.RPN by flow.RPN flow.RPN++ Set PKT_PROPERTY 可靠命中 Set FlowIndex </div> Else If NACK from MAC <div> Set PKT_PROPERTY 可靠命中 Set FlowIndex </div>	此表应在多队列模块之后，使得RPN值正确 在Deparser中，对于发向下游的DAT报文（非过路报文），Reliability_Send MAU用RSIP和DIP匹配，DAT报文同时发向MAC和可靠发送缓存模块；对于来自上游的NACK报文，Reliability_Send MAU用DstIP和SrcIP匹配，此NACK报文只发向可靠发送缓存模块；其他正常转发。
(Default)	Set PKT_PROPERTY 可靠未命中	

5. Parser默认动作

5.1 高可靠接收侧流水线Parser默认动作

对于IPv6包：进local表

对于非IPv6包：不做处理跳过本流水线

5.2 IDP流水线Parser默认动作

If Ourport 不为8b'0 （已指定出口）

跳过IDP流水线。

Else If Tid值不为0xff

设置对应的TableMask

If (local && (Protocol & ProPktinCsr != 0))

PKTIN

非IDP包，跳过IDP流水线，去IP转发流水线

IDP包：

if inport来自Host， SET local

NACK包：跳过IDP流水线，去IP转发流水线

NACK-Reply包：local 丢（置error）； 非local 转（跳过IDP流水线，去IP转发流水线）

default： Goto Dispatch

非PKTIN的error包，跳过流水线处理（error包：IPv6长度不对，IDP字段不对，local的NACK-Reply）

Deparser配套逻辑： 非PKTIN的Error包，Drop

5.3 IP转发流水线Parser默认动作

来自ctl的包不能再被PKTIN，drop

If Ourport 不为8b'0（已指定出口）

跳过IP转发流水线。

Else If Tid值不为0xff

设置对应的TableMask。如果Tid<本流水线的表号，从FIB_HOST处理

If (IDP||SCMP)

从FIB_HOST处理

Else

端口收发（mac转给host，host转给mac）

End

5.4 高可靠发送侧流水线Parser默认动作

对于idp包：

高可靠DAT传输包：local 进高可靠传输发侧表，置vaild；非local，跳过本流水线，不置valid

NACK包：local 置valid；非 local 跳过本流水线，不置valid。

NACK-Reply包：跳过本流水线，不置valid。

default：跳过本流水线，不置valid。

对于非idp包：不做处理，跳过本流水线。

6. 哈希矩阵

6.1流表和哈希矩阵的对应关系

6.2key位数等于128位

uint8_t hash128_1[128][11]={

{0x1,0x1,0x0,0x0,0x1,0x1,0x0,0x0,0x1,0x0,0x0},

{0x0,0x0,0x1,0x0,0x0,0x1,0x0,0x1,0x1,0x0,0x1},

{0x1,0x0,0x1,0x1,0x1,0x0,0x1,0x1,0x1,0x1,0x1},

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{0x1,0x1,0x1,0x1,0x0,0x1,0x0,0x1,0x0,0x0,0x0},
{0x0,0x0,0x0,0x0,0x1,0x1,0x0,0x0,0x0,0x0,0x1},
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{0x1,0x1,0x1,0x1,0x1,0x0,0x1,0x0,0x0,0x0,0x1},
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{0x0,0x1,0x1,0x1,0x1,0x0,0x1,0x1,0x0,0x0,0x1},

```
{0x1,0x0,0x0,0x0,0x0,0x1,0x1,0x1,0x0,0x0,0x1},  
};
```

```
uint8_t hash128_2[128][11]={
```

```
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```

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```
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};
```

```
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{0x1,0x1,0x1,0x0,0x0,0x0,0x0,0x1,0x1,0x0,0x0},  
};
```

{0x1,0x0,0x0,0x0,0x1,0x1,0x1,0x1,0x1,0x0,0x1},
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};
```

```
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```

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{0x1,0x1,0x0,0x1,0x0,0x1,0x0,0x1,0x0,0x0,0x1},
{0x1,0x1,0x1,0x1,0x0,0x1,0x1,0x1,0x0,0x1,0x0},
{0x0,0x0,0x0,0x0,0x0,0x0,0x1,0x0,0x0,0x0,0x1},
{0x1,0x1,0x0,0x0,0x1,0x1,0x0,0x0,0x0,0x1,0x0},
{0x0,0x1,0x0,0x0,0x1,0x0,0x1,0x1,0x0,0x1,0x1},


```
{0x0,0x0,0x1,0x1,0x0,0x1,0x1,0x0,0x1,0x1,0x0},
{0x0,0x1,0x0,0x0,0x0,0x0,0x1,0x0,0x0,0x1,0x1},
{0x1,0x0,0x1,0x1,0x0,0x1,0x0,0x1,0x1,0x0,0x0},
{0x0,0x0,0x1,0x0,0x0,0x1,0x1,0x0,0x0,0x0,0x1},
{0x1,0x0,0x0,0x0,0x1,0x0,0x0,0x1,0x0,0x1,0x1},
{0x0,0x0,0x1,0x1,0x0,0x1,0x1,0x1,0x0,0x1,0x1},
{0x1,0x0,0x1,0x1,0x0,0x0,0x1,0x1,0x1,0x1,0x1},
{0x1,0x0,0x1,0x0,0x1,0x0,0x1,0x0,0x0,0x0,0x1},
{0x0,0x0,0x0,0x1,0x1,0x1,0x1,0x0,0x1,0x1,0x1},
{0x1,0x0,0x1,0x1,0x1,0x0,0x1,0x0,0x1,0x0,0x0},
{0x1,0x1,0x0,0x0,0x1,0x1,0x0,0x1,0x1,0x0,0x1},
{0x1,0x0,0x0,0x0,0x1,0x1,0x0,0x1,0x0,0x1,0x0},
{0x1,0x0,0x1,0x1,0x0,0x1,0x1,0x1,0x0,0x1,0x1},
{0x0,0x0,0x1,0x0,0x0,0x1,0x1,0x0,0x1,0x0,0x1},
{0x0,0x1,0x0,0x1,0x1,0x1,0x1,0x0,0x1,0x1,0x0},
{0x0,0x0,0x1,0x0,0x1,0x0,0x0,0x0,0x0,0x1,0x0},
{0x0,0x1,0x1,0x0,0x1,0x1,0x1,0x0,0x1,0x0,0x0},
{0x1,0x1,0x0,0x0,0x1,0x1,0x1,0x1,0x1,0x0,0x1},
{0x1,0x1,0x0,0x0,0x0,0x1,0x1,0x0,0x0,0x1,0x0},
{0x1,0x0,0x1,0x0,0x1,0x1,0x1,0x1,0x0,0x0,0x1},
{0x0,0x0,0x0,0x1,0x0,0x0,0x1,0x0,0x1,0x0,0x1},
{0x0,0x1,0x0,0x0,0x0,0x1,0x1,0x1,0x0,0x1,0x1},
};
```

6.3key位数等于136位

```
hash136_4[136][9]={
{0x1,0x0,0x0,0x0,0x1,0x0,0x1,0x1,0x1},
{0x0,0x0,0x1,0x0,0x0,0x0,0x0,0x1,0x0},
{0x1,0x0,0x0,0x0,0x1,0x1,0x1,0x1,0x1},
{0x0,0x1,0x0,0x1,0x1,0x1,0x0,0x0,0x0},
{0x1,0x0,0x1,0x1,0x1,0x0,0x1,0x0,0x0},
```

{0x0,0x1,0x1,0x1,0x1,0x0,0x0,0x0,0x1},
{0x0,0x1,0x1,0x0,0x0,0x0,0x1,0x1,0x1},
{0x1,0x0,0x0,0x0,0x1,0x1,0x0,0x1,0x1},
{0x0,0x1,0x0,0x0,0x1,0x0,0x0,0x0,0x0},
{0x1,0x1,0x0,0x0,0x1,0x1,0x0,0x0,0x1},
{0x1,0x1,0x1,0x0,0x1,0x1,0x0,0x0,0x1},
{0x1,0x0,0x1,0x1,0x1,0x1,0x0,0x1,0x0},
{0x0,0x1,0x0,0x1,0x0,0x1,0x1,0x1,0x1},
{0x1,0x1,0x1,0x1,0x1,0x1,0x1,0x1,0x1},
{0x1,0x0,0x1,0x1,0x0,0x1,0x1,0x0,0x0},
{0x1,0x1,0x0,0x0,0x1,0x0,0x0,0x1,0x1},
{0x1,0x0,0x0,0x0,0x0,0x1,0x0,0x1,0x0},
{0x0,0x0,0x0,0x0,0x1,0x0,0x1,0x0,0x1},
{0x0,0x0,0x1,0x0,0x0,0x1,0x1,0x0,0x0},
{0x1,0x0,0x0,0x0,0x0,0x1,0x0,0x0,0x1},
{0x1,0x1,0x0,0x1,0x0,0x0,0x1,0x0,0x0},
{0x1,0x1,0x1,0x1,0x1,0x1,0x1,0x1,0x1},
{0x1,0x1,0x1,0x0,0x1,0x0,0x1,0x1,0x1},
{0x1,0x0,0x0,0x0,0x1,0x0,0x1,0x0,0x0},
{0x0,0x0,0x1,0x1,0x1,0x1,0x1,0x1,0x0},
{0x1,0x1,0x0,0x0,0x1,0x1,0x0,0x1,0x1},
{0x1,0x1,0x0,0x0,0x0,0x1,0x1,0x0,0x0},
{0x1,0x0,0x0,0x1,0x1,0x1,0x1,0x1,0x1},
{0x0,0x0,0x1,0x0,0x1,0x0,0x0,0x0,0x0},
{0x1,0x1,0x1,0x1,0x1,0x1,0x0,0x0,0x1},
{0x0,0x0,0x1,0x0,0x1,0x1,0x0,0x1,0x1},
{0x0,0x0,0x0,0x0,0x1,0x1,0x1,0x0,0x0},
{0x1,0x0,0x1,0x1,0x0,0x0,0x1,0x0,0x1},
{0x0,0x0,0x0,0x1,0x1,0x0,0x1,0x1,0x1},
{0x1,0x0,0x0,0x1,0x1,0x0,0x0,0x0,0x1},
{0x0,0x1,0x1,0x0,0x0,0x1,0x0,0x0,0x1},

{0x0,0x0,0x0,0x1,0x0,0x0,0x0,0x0,0x1},
{0x1,0x1,0x1,0x0,0x0,0x0,0x1,0x1,0x0},
{0x1,0x1,0x0,0x0,0x1,0x0,0x0,0x0,0x1},
{0x1,0x1,0x1,0x0,0x0,0x1,0x1,0x1,0x0},
{0x0,0x1,0x1,0x1,0x1,0x0,0x1,0x1,0x0},
{0x0,0x1,0x1,0x0,0x0,0x0,0x0,0x1,0x1},
{0x0,0x1,0x1,0x0,0x0,0x1,0x0,0x1,0x0},
{0x0,0x1,0x1,0x1,0x0,0x1,0x0,0x0,0x0},
{0x1,0x1,0x0,0x0,0x1,0x0,0x1,0x1,0x1},
{0x0,0x1,0x1,0x0,0x1,0x0,0x0,0x0,0x1},
{0x0,0x0,0x0,0x1,0x1,0x1,0x1,0x1,0x0},
{0x1,0x0,0x0,0x1,0x1,0x1,0x1,0x1,0x1},
{0x1,0x1,0x1,0x0,0x1,0x0,0x0,0x1,0x1},
{0x1,0x1,0x1,0x1,0x1,0x0,0x0,0x0,0x1},
{0x1,0x0,0x1,0x0,0x0,0x0,0x0,0x1,0x0},
{0x0,0x1,0x1,0x0,0x0,0x0,0x1,0x0,0x0},
{0x1,0x0,0x1,0x1,0x1,0x1,0x0,0x0,0x0},
{0x0,0x0,0x1,0x0,0x1,0x1,0x0,0x0,0x0},
{0x0,0x0,0x0,0x1,0x1,0x0,0x0,0x1,0x0},
{0x0,0x1,0x0,0x0,0x1,0x0,0x1,0x0,0x0},
{0x0,0x0,0x1,0x0,0x1,0x1,0x1,0x1,0x1},
{0x1,0x1,0x1,0x1,0x1,0x0,0x0,0x1,0x0},
{0x1,0x1,0x1,0x1,0x1,0x1,0x1,0x0,0x0},
{0x1,0x1,0x1,0x1,0x0,0x0,0x1,0x1,0x1},
{0x0,0x0,0x1,0x0,0x1,0x1,0x0,0x1,0x1},
{0x1,0x0,0x0,0x0,0x1,0x0,0x1,0x1,0x1},
{0x1,0x1,0x1,0x1,0x0,0x0,0x1,0x0,0x1},
{0x0,0x0,0x1,0x0,0x1,0x0,0x1,0x0,0x1},
{0x0,0x1,0x0,0x0,0x0,0x0,0x0,0x0,0x0},
{0x0,0x1,0x1,0x1,0x1,0x1,0x1,0x0,0x0},
{0x1,0x1,0x1,0x1,0x1,0x0,0x1,0x1,0x1},

{0x1,0x1,0x0,0x1,0x1,0x1,0x1,0x1,0x0},
{0x1,0x1,0x1,0x0,0x1,0x1,0x1,0x1,0x1},
{0x0,0x1,0x1,0x0,0x1,0x1,0x0,0x1,0x0},
{0x0,0x1,0x1,0x0,0x1,0x0,0x1,0x0,0x1},
{0x0,0x0,0x0,0x1,0x0,0x0,0x1,0x1,0x1},
{0x1,0x1,0x1,0x0,0x0,0x1,0x0,0x0,0x0},
{0x0,0x1,0x0,0x0,0x1,0x1,0x0,0x1,0x0},
{0x1,0x0,0x0,0x1,0x0,0x0,0x1,0x1,0x0},
{0x0,0x1,0x0,0x0,0x1,0x1,0x1,0x0,0x0},
{0x0,0x1,0x0,0x1,0x0,0x1,0x1,0x0,0x1},
{0x0,0x0,0x1,0x1,0x1,0x0,0x0,0x1,0x0},
{0x0,0x0,0x1,0x0,0x1,0x1,0x0,0x0,0x1},
{0x0,0x1,0x1,0x0,0x1,0x0,0x1,0x1,0x1},
{0x1,0x1,0x0,0x0,0x0,0x1,0x1,0x1,0x1},
{0x0,0x0,0x1,0x1,0x0,0x1,0x0,0x1,0x0},
{0x1,0x0,0x1,0x0,0x1,0x1,0x1,0x0,0x0},
{0x1,0x1,0x1,0x1,0x1,0x1,0x0,0x0,0x1},
{0x1,0x1,0x1,0x0,0x0,0x1,0x1,0x0,0x1},
{0x1,0x1,0x1,0x0,0x0,0x0,0x0,0x1,0x1},
{0x0,0x0,0x0,0x1,0x0,0x0,0x1,0x0,0x1},
{0x1,0x1,0x0,0x0,0x0,0x0,0x1,0x0,0x1},
{0x0,0x0,0x1,0x0,0x1,0x1,0x1,0x0,0x1},
{0x0,0x1,0x1,0x1,0x0,0x1,0x1,0x0,0x0},
{0x1,0x0,0x1,0x0,0x1,0x0,0x1,0x0},
{0x1,0x0,0x0,0x1,0x1,0x1,0x1,0x0,0x0},
{0x1,0x0,0x1,0x1,0x1,0x1,0x0,0x0,0x1},
{0x0,0x0,0x1,0x1,0x1,0x1,0x0,0x1,0x1},
{0x1,0x0,0x1,0x1,0x1,0x0,0x0,0x0,0x0},
{0x0,0x0,0x1,0x1,0x1,0x1,0x1,0x1,0x1},
{0x0,0x1,0x0,0x1,0x0,0x1,0x1,0x0,0x0},
{0x0,0x1,0x0,0x1,0x0,0x1,0x1,0x1,0x0},

{0x0,0x1,0x0,0x1,0x1,0x0,0x1,0x1,0x1},
{0x0,0x0,0x0,0x1,0x1,0x0,0x1,0x0,0x0},
{0x1,0x1,0x0,0x0,0x1,0x0,0x0,0x0,0x0},
{0x1,0x0,0x0,0x1,0x1,0x0,0x0,0x1,0x1},
{0x0,0x1,0x1,0x1,0x0,0x1,0x0,0x0,0x1},
{0x0,0x1,0x0,0x1,0x1,0x1,0x1,0x1,0x1},
{0x0,0x0,0x1,0x0,0x0,0x1,0x1,0x0,0x0},
{0x1,0x0,0x0,0x1,0x1,0x1,0x0,0x0,0x0},
{0x0,0x0,0x0,0x0,0x0,0x1,0x1,0x1,0x1},
{0x0,0x1,0x1,0x1,0x1,0x0,0x1,0x1,0x1},
{0x0,0x0,0x1,0x0,0x0,0x0,0x0,0x0,0x1},
{0x1,0x0,0x1,0x0,0x0,0x1,0x1,0x0,0x1},
{0x0,0x1,0x1,0x0,0x0,0x0,0x0,0x1,0x0},
{0x1,0x1,0x0,0x1,0x1,0x0,0x1,0x1,0x1},
{0x1,0x0,0x1,0x0,0x1,0x1,0x0,0x0,0x1},
{0x1,0x1,0x1,0x1,0x1,0x1,0x1,0x1,0x1},
{0x1,0x0,0x0,0x1,0x1,0x1,0x0,0x1,0x0},
{0x0,0x1,0x1,0x1,0x0,0x0,0x1,0x1,0x0},
{0x0,0x0,0x1,0x0,0x1,0x0,0x0,0x0,0x1},
{0x0,0x0,0x1,0x0,0x0,0x0,0x0,0x0,0x0},
{0x1,0x1,0x0,0x0,0x1,0x0,0x1,0x0,0x1},
{0x0,0x1,0x0,0x1,0x0,0x0,0x0,0x0,0x0},
{0x1,0x1,0x1,0x0,0x1,0x1,0x1,0x0,0x0},
{0x1,0x1,0x0,0x0,0x0,0x0,0x1,0x0,0x0},
{0x0,0x1,0x0,0x1,0x0,0x0,0x0,0x0,0x0},
{0x1,0x1,0x1,0x0,0x1,0x1,0x1,0x0,0x0},
{0x0,0x0,0x0,0x1,0x0,0x1,0x1,0x0,0x1},
{0x0,0x0,0x0,0x1,0x1,0x1,0x1,0x1,0x0},
{0x1,0x1,0x0,0x1,0x1,0x0,0x0,0x1,0x1},
{0x1,0x1,0x0,0x0,0x0,0x1,0x1,0x0,0x0},
{0x1,0x1,0x0,0x0,0x1,0x1,0x0,0x0,0x0},
{0x0,0x1,0x1,0x1,0x1,0x0,0x0,0x1,0x1},
{0x0,0x1,0x1,0x1,0x1,0x0,0x0,0x1,0x0},

```
{0x0,0x1,0x1,0x1,0x0,0x1,0x0,0x1,0x0},  
{0x1,0x0,0x0,0x1,0x0,0x1,0x1,0x1,0x1},  
{0x0,0x0,0x0,0x0,0x0,0x0,0x0,0x1,0x0},  
{0x0,0x0,0x0,0x1,0x0,0x1,0x0,0x1,0x1},  
{0x1,0x1,0x0,0x1,0x0,0x0,0x0,0x0,0x0},  
{0x1,0x1,0x0,0x0,0x1,0x0,0x1,0x0,0x0},  
{0x0,0x1,0x1,0x0,0x1,0x1,0x0,0x0,0x0},  
};
```

6.4key位数等于160位

```
uint8_t hash160_1[160][11]={  
{0x0,0x0,0x0,0x0,0x1,0x1,0x0,0x0,0x1,0x0,0x1},  
{0x0,0x0,0x0,0x0,0x0,0x0,0x1,0x1,0x0,0x1,0x1},  
{0x0,0x1,0x0,0x0,0x0,0x0,0x1,0x1,0x0,0x0,0x0},  
{0x0,0x1,0x0,0x1,0x1,0x1,0x1,0x1,0x0,0x0,0x0},  
{0x1,0x0,0x1,0x1,0x0,0x0,0x1,0x1,0x0,0x1,0x1},  
{0x0,0x0,0x1,0x1,0x0,0x0,0x0,0x1,0x0,0x0,0x0},  
{0x1,0x0,0x1,0x1,0x1,0x1,0x0,0x1,0x1,0x0,0x0},  
{0x0,0x1,0x0,0x1,0x1,0x0,0x1,0x1,0x1,0x0,0x1},  
{0x1,0x0,0x0,0x0,0x0,0x0,0x0,0x0,0x1,0x0,0x1},  
{0x0,0x0,0x1,0x1,0x0,0x0,0x1,0x0,0x1,0x0,0x0},  
{0x1,0x0,0x1,0x0,0x1,0x1,0x1,0x0,0x0,0x1,0x0},  
{0x1,0x1,0x1,0x1,0x1,0x0,0x0,0x1,0x0,0x0,0x1},  
{0x0,0x1,0x0,0x1,0x0,0x0,0x0,0x1,0x0,0x1,0x1},  
{0x1,0x1,0x1,0x0,0x0,0x0,0x1,0x1,0x0,0x0,0x0},  
{0x0,0x1,0x0,0x1,0x0,0x1,0x1,0x0,0x0,0x1,0x1},  
{0x0,0x0,0x0,0x1,0x0,0x0,0x1,0x1,0x0,0x0,0x0},  
{0x1,0x0,0x1,0x1,0x1,0x0,0x1,0x0,0x0,0x0,0x0},  
{0x1,0x0,0x1,0x0,0x1,0x0,0x1,0x0,0x0,0x0,0x1},  
{0x1,0x0,0x1,0x0,0x1,0x1,0x1,0x0,0x1,0x1,0x1},  
{0x0,0x1,0x0,0x1,0x0,0x1,0x0,0x0,0x0,0x0,0x0},
```

{0x0,0x0,0x0,0x1,0x1,0x0,0x1,0x0,0x1,0x1,0x0},
{0x0,0x0,0x0,0x0,0x0,0x1,0x1,0x0,0x1,0x0,0x1},
{0x1,0x1,0x1,0x1,0x1,0x1,0x0,0x1,0x0,0x1,0x0},
{0x1,0x1,0x0,0x1,0x1,0x0,0x1,0x1,0x0,0x1,0x1},
{0x1,0x0,0x1,0x0,0x0,0x1,0x0,0x0,0x0,0x0,0x1},
{0x1,0x1,0x0,0x0,0x1,0x0,0x0,0x1,0x1,0x1,0x1},
{0x0,0x1,0x1,0x1,0x0,0x1,0x1,0x0,0x1,0x0,0x0},
{0x0,0x0,0x0,0x0,0x1,0x0,0x0,0x0,0x1,0x1,0x1},
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```

```
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```
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};
```

```
uint8_t hash160_4[160][11]={
```

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{0x1,0x1,0x0,0x0,0x0,0x1,0x1,0x1,0x1,0x1,0x1},
{0x1,0x1,0x0,0x1,0x0,0x1,0x1,0x1,0x1,0x1,0x0},
{0x0,0x0,0x0,0x1,0x1,0x1,0x1,0x1,0x1,0x1,0x0},
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{0x0,0x0,0x1,0x1,0x0,0x0,0x0,0x0,0x0,0x1,0x0},

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{0x0,0x1,0x1,0x0,0x1,0x0,0x0,0x1,0x1,0x0,0x1},

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{0x1,0x0,0x1,0x1,0x1,0x0,0x1,0x1,0x1,0x0,0x0},
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{0x1,0x0,0x1,0x0,0x0,0x1,0x0,0x1,0x1,0x0,0x1},
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{0x1,0x0,0x0,0x1,0x1,0x0,0x1,0x0,0x0,0x0,0x0},
{0x0,0x0,0x1,0x0,0x1,0x0,0x1,0x1,0x1,0x1,0x0},

```
{0x0,0x1,0x1,0x0,0x0,0x1,0x1,0x1,0x1,0x1,0x1},
{0x1,0x1,0x0,0x1,0x0,0x1,0x1,0x1,0x1,0x1,0x1},
{0x0,0x1,0x1,0x1,0x0,0x0,0x1,0x0,0x1,0x1,0x1},
{0x0,0x1,0x1,0x0,0x0,0x1,0x0,0x0,0x0,0x1,0x0},
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{0x1,0x1,0x1,0x1,0x0,0x0,0x1,0x0,0x1,0x0,0x1},
{0x0,0x1,0x1,0x0,0x0,0x0,0x1,0x0,0x1,0x1,0x1},
{0x0,0x1,0x0,0x1,0x0,0x1,0x1,0x0,0x0,0x1,0x1},
{0x0,0x1,0x0,0x1,0x0,0x0,0x0,0x0,0x1,0x0,0x1},
};
```

6.5key位数等于256位

```
uint8_t hash256_1[256][9]={
{0x0,0x0,0x1,0x1,0x0,0x1,0x1,0x0,0x1},
{0x1,0x0,0x0,0x1,0x0,0x0,0x0,0x1,0x1},
{0x1,0x0,0x0,0x1,0x0,0x1,0x1,0x1,0x1},
{0x0,0x0,0x1,0x0,0x1,0x0,0x0,0x1,0x0},
{0x1,0x0,0x0,0x1,0x1,0x1,0x0,0x0,0x0},
{0x0,0x0,0x0,0x0,0x1,0x1,0x1,0x0,0x0},
{0x0,0x0,0x1,0x0,0x1,0x1,0x0,0x1,0x0},
{0x0,0x1,0x0,0x0,0x1,0x0,0x0,0x1,0x1},
{0x1,0x0,0x1,0x0,0x1,0x1,0x0,0x0,0x1},
{0x1,0x0,0x1,0x0,0x1,0x1,0x1,0x0,0x1},
{0x0,0x0,0x1,0x1,0x1,0x1,0x0,0x1,0x0},
{0x0,0x1,0x1,0x0,0x0,0x1,0x1,0x1,0x0},
{0x1,0x1,0x1,0x1,0x0,0x0,0x1,0x1,0x1},
{0x0,0x1,0x0,0x0,0x0,0x0,0x0,0x1,0x1},
{0x1,0x1,0x1,0x0,0x1,0x1,0x0,0x1,0x0},
{0x1,0x0,0x1,0x0,0x1,0x1,0x1,0x1,0x0},
{0x1,0x1,0x1,0x1,0x0,0x0,0x0,0x1,0x0},
{0x0,0x0,0x0,0x0,0x1,0x0,0x0,0x0,0x0},
```

{0x1,0x1,0x0,0x1,0x0,0x0,0x0,0x0,0x1},
{0x0,0x1,0x1,0x1,0x1,0x1,0x1,0x1,0x0},
{0x1,0x1,0x0,0x0,0x0,0x1,0x1,0x1,0x0},
{0x0,0x1,0x0,0x1,0x1,0x1,0x0,0x0,0x0},
{0x0,0x1,0x1,0x0,0x0,0x0,0x0,0x0,0x0},
{0x1,0x1,0x0,0x0,0x1,0x0,0x1,0x1,0x0},
{0x0,0x0,0x1,0x1,0x0,0x1,0x1,0x0,0x0},
{0x1,0x0,0x0,0x1,0x0,0x0,0x0,0x0,0x1},
{0x0,0x1,0x0,0x0,0x1,0x1,0x1,0x0,0x1},
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{0x0,0x0,0x0,0x1,0x1,0x1,0x1,0x1,0x0},
{0x0,0x0,0x0,0x1,0x0,0x1,0x1,0x0,0x1},
{0x0,0x1,0x0,0x1,0x0,0x1,0x0,0x0,0x1},
{0x1,0x1,0x1,0x0,0x0,0x1,0x0,0x1,0x1},
{0x0,0x0,0x1,0x0,0x1,0x0,0x1,0x0,0x1},

{0x1,0x0,0x1,0x1,0x0,0x0,0x0,0x0,0x1},
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```
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{0x0,0x0,0x1,0x0,0x1,0x1,0x1,0x1,0x0},  
{0x1,0x1,0x1,0x0,0x1,0x0,0x0,0x0,0x0},  
{0x1,0x0,0x1,0x1,0x0,0x1,0x1,0x1,0x1},  
};
```

```
uint8_t hash256_4[256][9]={
```

```
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```

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