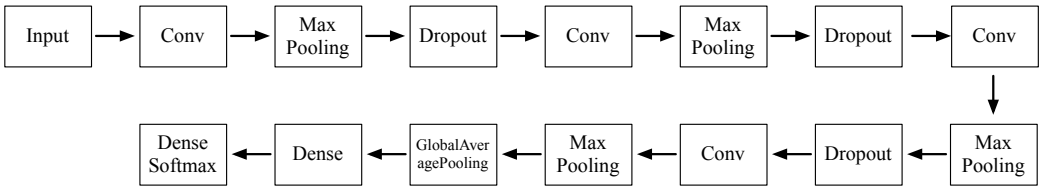


Figure 9: The structure of our CNN model.

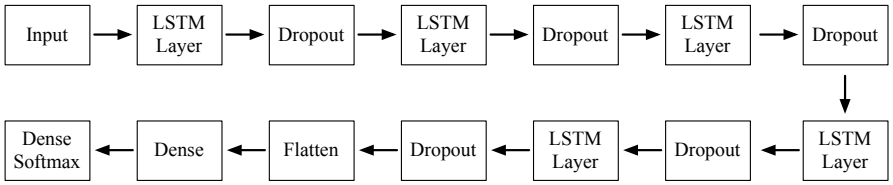


Figure 10: The structure of our LSTM model.

Table 9: Tuned Hyperparameters of Each Model with Both Outgoing and Incoming Traffic in the Numerical Format

Hyperparameters	Search Space	CNN	LSTM	SAE
Input Dimension	{300, 325, 350, ..., 575, 600}	475	350	375
Optimizer	{Adam, SGD, Adamax, Adadelta}	Adamax	Adamax	Adam
Learning Rate	{0.001, 0.002, 0.01, 0.05, 0.1}	0.002	0.002	0.001
Decay	{0.00, 0.01, 0.02, ..., 0.50}	0.13	0.19	0.30
Batch Size	{30, 40, 50, ..., 120, 130}	70	130	110
Activation Function	{softsigh, tanh, elu, selu}	[tanh; elu; elu; selu || selu]	[tanh; tanh; tanh; tanh || selu]	[elu; tanh; selu; elu; softsign || tanh]
Dropout	{0.0, 0.1, 0.2, 0.3, 0.4, 0.5}	[0.1; 0.3; 0.1; 0.0]	[0.4; 0.1; 0.1; 0.3; 0.5]	[0.2; 0.0; 0.0; 0.3]
Dense Layer Size	{100, 110, 120, ..., 170, 180}	180	70	130
Convolution Number	{16, 32, 64, 128, 256}	[128; 128; 64; 256]	–	–
Filter Size	{7, 9, 11, ..., 25, 27}	[7; 19; 13; 23]	–	–
Pool Size	{1, 3, 5, 7}	[1; 1; 1; 1]	–	–
LSTM Layer Size	{90, 100, 110,..., 300, 310}	–	[210; 190; 190; 190; 130]	–
SAE Encoder Layer Size	{200, 210, ..., 390, 400}	–	–	[330; 260; 330; 280; 250]

Table 10: Tuned Hyperparameters of Each Model with Incoming Traffic Only in the Numerical Format

Hyperparameters	Search Space	CNN	LSTM	SAE
Input Dimension	{300, 325, 350, ..., 575, 600}	450	500	350
Optimizer	{Adam, SGD, Adamax, Adadelta}	Adam	Adamax	Adadelta
Learning Rate	{0.001, 0.002, 0.01, 0.05, 0.1}	0.002	0.002	1.0
Decay	{0.00, 0.01, 0.02, ..., 0.50}	0.50	0.20	0.30
Batch Size	{30, 40, 50, ..., 120, 130}	150	170	130
Activation Function	{softsigh, tanh, elu, selu}	[tanh; selu; elu; selu || selu]	[tanh; tanh; tanh; tanh || elu]	[elu; selu; selu; softsign; tanh || elu]
Dropout	{0.0, 0.1, 0.2, 0.3, 0.4, 0.5}	[0.2; 0.1; 0.4; 0.5]	[0.1; 0; 0.1; 0; 0.1, 0.5]	[0.1; 0.0; 0.0; 0.0]
Dense Layer Size	{100, 110, 120, ..., 170, 180}	140	150	160
Convolution Number	{16, 32, 64, 128, 256}	[256; 32; 128; 32]	–	–
Filter Size	{7, 9, 11, ..., 25, 27}	[9; 9; 11; 15]	–	–
Pool Size	{1, 3, 5, 7}	[3; 2; 1; 2]	–	–
LSTM Layer Size	{90, 100, 110,..., 300, 310}	–	[170; 290; 170; 90; 250]	–
SAE Encoder Layer Size	{200, 210, ..., 390, 400}	–	–	[330; 290; 270; 250; 220]

APPENDIX

Framework of Neural Networks. Fig. 9 shows the framework of our CNN model. Fig. 10 describes the framework of our LSTM model. Fig. 11 presents the framework of our SAE model.

Tuned Hyperparameters. In Table 9, we present the search spaces of the three models with both incoming and outgoing traffic in the numeric format. For the search space of each hyperparameter, we represent it as a set. We searched for learning rate and decay values if the optimizer is Stochastic Gradient Decent (SGD). If the tuned optimizer is not SGD, we used the default learning rate and decay provided by `Keras`. For the activation functions, dropout, filter size and pool size, we searched for hyperparameters at each layer. For each of these, the tuned parameters we report in the table are presented as a sequence of values by following the order of layers we presented in Fig. 9, Fig. 10, and Fig. 11. For instance, for

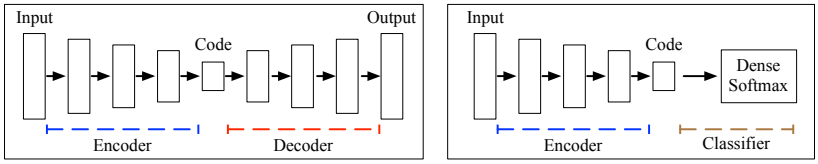


Figure 11: The structure of our SAE model. Encoder and code are trained in training (left) and used in classification (right).

Table 11: The monitored list of voice commands in the closed-world setting.

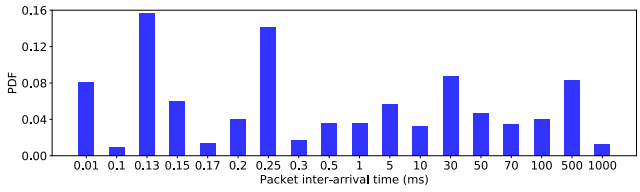
Index	Voice Command	Index	Voice Command
1	Are you wearing green?	51	What is gluten?
2	Announce Happy Valentines Day.	52	What is Homecoming about?
3	Do dogs dream?	53	What is my sports update?
4	Do you like cats or dogs?	54	What is my traffic report?
5	Flip a coin.	55	What is on your mind?
6	Give me a dinosaur fact.	56	What is Roblox?
7	Give me a fun fact about sleep.	57	What is the AFC North Standings?
8	Good Morning.	58	What is the best comedy movie?
9	Help.	59	What is the capital of Spain?
10	How deep is the Indian Ocean?	60	What is the date tomorrow?
11	How do you spell appreciate?	61	What is the fourth book in the Narnia series?
12	How far away is the moon?	62	What is the history of Labor Day?
13	How hot is the sun?	63	What is the longest word?
14	How many days are in September?	64	What is the number one song this week?
15	How many days in a year?	65	What is the price of bitcoin?
16	How many days until Christmas?	66	What is the scariest movie of all time?
17	How many days until Thanksgiving?	67	What is the score of the Eagles game?
18	How many fantasy points does LeBron James have?	68	What is the score of the Red Sox game?
19	How many ounces in a pound?	69	What is the time in Singapore?
20	How many seconds are in a year?	70	What is the weather for Sunday?
21	How many teaspoons are in a tablespoon?	71	What is the weather?
22	How much does an elephant weigh?	72	What is trending?
23	How much is an ounce of gold?	73	What is your favorite flower?
24	How old are you?	74	What is your favorite game?
25	How old is Henry Winkler?	75	What is your favorite hobby?
26	How old is Serena Williams?	76	What is your favorite sport?
27	How tall is Steph Curry?	77	What is your mission?
28	How tall is the Empire State Building?	78	What is zero divided by zero?
29	How tall is The Rock?	79	What movies are playing?
30	Is a tomato a fruit or a vegetable?	80	What were yesterdays scores?
31	Pick a number?	81	When does daylight saving time end?
32	Surprise me.	82	When does Game of Thrones return?
33	Talk like a pirate.	83	When is Boxing Day?
34	Tell me a barbecue joke.	84	When is Hanukkah?
35	Tell me a coffee joke.	85	When is the NBA all star game?
36	Tell me a fun fact.	86	When is the next full moon?
37	Tell me a Halloween hack.	87	Where did Yoda live?
38	Tell me a joke.	88	Where is Mount Rushmore?
39	Tell me a palindrome	89	Who do you love?
40	Tell me a Star Wars joke.	90	Who is in Mastodon?
41	Tell me some good news.	91	Who is nominated for best actor?
42	Tell me something weird.	92	Who is playing Monday Night Football?
43	Translate good morning to Spanish.	93	Who is second in the NBA Western Conference?
44	What are some flower shops nearby?	94	Who is winning the World Series?
45	What are the most popular books this week?	95	Who is your favorite author?
46	What are the standings in the English Premier League?	96	Who is your favorite poet?
47	What are you thankful for?	97	Who is your favorite superhero?
48	What can you do?	98	Who scored for the Golden Knights?
49	What happened in the midterm elections?	99	Why do leaves change color in the fall?
50	What is brief mode?	100	Will it rain tomorrow?

our CNN model, the tuned activation functions are `tanh` (1st Conv), `elu` (2nd Conv), `elu` (3rd Conv) and `selu` (4th Conv). The `selu` after symbol || in the table means that the second to last dense layer in our CNN uses `selu` as its activation function. Note that, we did not include `relu` as one of the activation functions in the search space. It is because `relu` maps all the negative values (the sizes of all the incoming packets) to 0s, which is not suitable for traffic analysis and has been pointed out in a previous study [38].

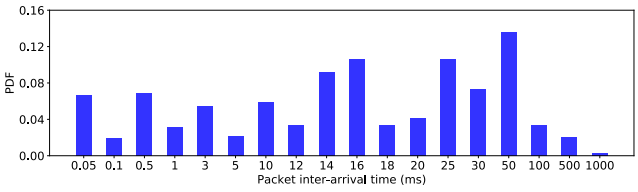
The hyperparameters we found with inputs in the binary format were similar but not exactly the same as the ones in numeric format. Due to space limitation, we skip the details. The hyperparameters

Table 12: The unmonitored list of voice commands in the open-world setting.

Index	Voice Command	Index	Voice Command
1	Are you skynet?	51	What are you reading?
2	Beatbox for me	52	What can I do with more than one Echo device?
3	Can you auto-tune?	53	What is 90 degrees Fahrenheit in Celsius?
4	Can you do an impression?	54	What is Carrie Underwood's net worth?
5	Can you rap?	55	What is pi?
6	Convert one pound to ounces	56	What is the dollar to euro exchange rate?
7	Define lexicon	57	What is Don't Worry, He Won't Get Far on Foot movie about?
8	Do the hokey pokey?	58	What is the next book by Rachel Hollis?
9	Drum roll please	59	What is the stock price of General Motors?
10	Give me a blooper	60	What is the tallest animal?
11	Give me a palindrome	61	What is the tallest mountain?
12	Give me a patriots burn.	62	What is the upcoming book by Neil Gaiman?
13	Give me a prank	63	What languages can you translate?
14	Give me a shark limerick	64	What should I be for Halloween?
15	Give me some bad poetry.	65	What time are the Emmys?
16	How are you?	66	What time does L.A. Fitness close?
17	How did Dow Jones do today?	67	What time is Big Brother on TV?
18	How do I keep my family in sync?	68	What is the birthday roundup?
19	How do I play music everywhere?	69	What is the most popular TV show?
20	How do I say happy birthday in Korean?	70	What is the net worth of Jennifer Lawrence?
21	How do you say happy birthday in Chinese?	71	What is your favorite word?
22	How does the intercom work?	72	When do I have to register to vote?
23	How many calories are in a donut?	73	When does Avengers: Endgame release in theaters?
24	How many gallons of water are in the Atlantic Ocean?	74	When does fall begin?
25	How many hits did Derek Jeter have in 2012?	75	When does the new season of The Walking Dead premiere?
26	How many people live in China?	76	When does Wimbledon start?
27	How many people live in New York?	77	When is April Fools Day?
28	How many rushing yards did Emmitt Smith have in his career?	78	When is Shark Week?
29	How many times has Duke been to the Final Four?	79	When is the autumn equinox?
30	How much does a Lamborghini cost?	80	When is the next lunar eclipse?
31	How old is Queen Elizabeth?	81	When is the Patriots' first game?
32	Is a hot dog a sandwich?	82	When is the Tour de France?
33	Make animal noises	83	When was McDonald's founded?
34	Pretend to be a supervillain	84	Where is the MLB All-Star game being played?
35	Rap about the cloud	85	Who does Alabama play in their first game?
36	Recite a haiku	86	Who inspires you?
37	Release the Kraken	87	Who invented GPS?
38	Roll the dice	88	Who is leading the Players Championship?
39	Sing a song for the 4th of July	89	Who is Peppa Pig?
40	Star Wars or Star Trek	90	Who is Rainbow Dash?
41	Tell me a baseball story	91	Who is running for Senate in California?
42	Tell me a basketball joke	92	Who is your favorite baseball player?
43	Tell me a giraffe fact	93	Who is your favorite Pokémon?
44	Tell me a joke about you	94	Who leads the WNBA in scoring?
45	Tell me a pun	95	Who signed the Declaration of Independence?
46	Tell me a shark joke	96	Who stars in Gringo?
47	Tell me a tongue twister	97	Who won the Winter Classic?
48	What are some good Halloween movies to watch?	98	Who is going to win the Final Four?
49	What are the best books of the year so far?	99	Who is hosting Saturday Night Live this weekend?
50	What are the rarest skins in Fortnite?	100	Who is your favorite college basketball team?



(a) Inter-arrival time distribution of incoming packets.



(b) Inter-arrival time distribution of outgoing packets.

Figure 12: The distribution of packet inter-arrival time.

with incoming traffic only with the numeric format are presented in Table 10.

Packet Inter-arrival Time. Fig. 12 describes the distribution of packet interarrival time in Amazon Echo dataset. We leveraged this distribution to perform adaptive padding in our defense.