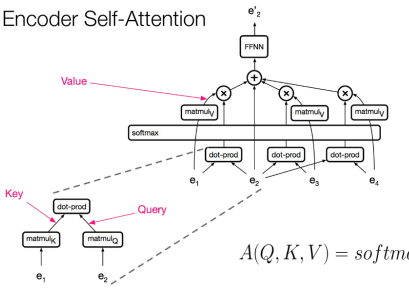
Attention

Encoder Self-Attention



$$A(Q,K,V) = softmax(\frac{QK^T}{\sqrt{d_k}})V$$

```python
def scaled_dot_product_attention(q, k, v, mask):
  """Calculate the attention weights.
  q, k, v must have matching leading dimensions.
  k, v must have matching penultimate dimension, i.e.: seq_len_k = seq_len_v.
  The mask has different shapes depending on its type(padding or look ahead)
  but it must be broadcastable for addition.

  Args:
    q: query shape == (..., seq_len_q, depth)
    k: key shape == (..., seq_len_k, depth)
    v: value shape == (..., seq_len_v, depth_v)
    mask: Float tensor with shape broadcastable
          to (..., seq_len_q, seq_len_k). Defaults to None.

  Returns:
    output, attention_weights
  """

  matmul_qk = tf.matmul(q, k, transpose_b=True)  # (..., seq_len_q, seq_len_k)

  # scale matmul_qk
  dk = tf.cast(tf.shape(k)[-1], tf.float32)
  scaled_attention_logits = matmul_qk / tf.math.sqrt(dk)

  # add the mask to the scaled tensor.
  if mask is not None:
    scaled_attention_logits += (mask * -1e9)

  # softmax is normalized on the last axis (seq_len_k) so that the scores
  # add up to 1.
  attention_weights = tf.nn.softmax(scaled_attention_logits, axis=-1)  # (..., seq_len_q, seq_len_k)

  output = tf.matmul(attention_weights, v)  # (..., seq_len_q, depth_v)

  return output, attention_weights
```

```python
temp_k = tf.constant([[10,0,0],  # (4, 3)
                      [0,10,0],
                      [0,0,10],
                      [0,0,10]], dtype=tf.float32)

temp_v = tf.constant([[   1,0],
                      [  10,0],
                      [ 100,5],
                      [1000,6]], dtype=tf.float32)  # (4, 2)

# This `query` aligns with the second `key`,
# so the second `value` is returned.
temp_q = tf.constant([[0, 10, 0]], dtype=tf.float32)  # (1, 3)
print_out(temp_q, temp_k, temp_v)
```

```python
def print_out(q, k, v):
  temp_out, temp_attn = scaled_dot_product_attention(
      q, k, v, None)
  print ('Attention weights are:')
  print (temp_attn)
  print ('Output is:')
  print (temp_out)
```

one query → one response

```
Attention weights are:
tf.Tensor([[0.  0.  0.5 0.5]], shape=(1, 4), dtype=float32)
Output is:
tf.Tensor([[550.    5.5]], shape=(1, 2), dtype=float32)
```

Response - is weighted representation of values (words) according to query

Let's say :

w1 = a cat
w2 = playing with
W3 = a ball
w4 = and a strip

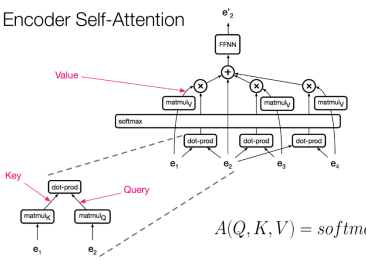
Query -> what cat is playing with?

Response -> 0.5 * ball and 0.5 * strip
0.5 *[100, 5] + 0.5 * [1000, 6] =[550, 5.5]

```python
temp_q = tf.constant([[0, 0, 10], [0, 10, 0], [10, 10, 0]], dtype=tf.float32)  # (3, 3)
print_out(temp_q, temp_k, temp_v)
```

```
Attention weights are:
tf.Tensor(
[[0.  0.  0.5 0.5]
 [0.  1.  0.  0. ]
 [0.5 0.5 0.  0. ]], shape=(3, 4), dtype=float32)
Output is:
tf.Tensor(
[[550.    5.5]
 [ 10.    0. ]
 [  5.5   0. ]], shape=(3, 2), dtype=float32)
```

Encoder Self-Attention



$$A(Q,K,V) = softmax(\frac{QK^T}{\sqrt{d_k}})V$$

For each word we get a Key and return a Response based on Query

In first layers we can create a transformations where each word is represented through itself
it means Len(Query) = Len(Keys)

However, number of Queries to one sentence should not be one to one.